Case studies of alternative approaches to mathematics teaching : situated cognition, sex and setting.

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Abstract

In this thesis I present the results of three-year case studies of two schools. 'Amber Hill' school was a traditional comprehensive that taught mathematics using textbooks. 'Phoenix Park' was a 'progressive' institution that taught mathematics using open-ended projects. As part of the research I followed a year group of students from year 9 to year 11, investigating the nature and form of the processes that influenced their developing understanding of mathematics. My analysis of the students' contrasting experiences draws upon a range of qualitative and quantitative methods including approximately one-hundred lesson observations in each school, in-depth interviews with teachers and students, student questionnaires and the results of various forms of assessment such as traditional tests, applied tasks and GCSE examinations.

The results of this study show that the learning of the students at the two schools differed in a number of important ways. At Amber Hill many of the students developed a limited, procedural knowledge that they were unable to use in new or demanding situations. This appeared to be due to their perceptions about mathematics, their understanding of mathematics and the goals they formed in different situations. At Phoenix Park many of the students were able to use mathematics in a variety of different settings. Their classroom environment had enculturated them into a way of thinking and interpreting, that appeared to advantage them in different communities of practice. The results of this study will also show that it was the traditional features of Amber Hill school's mathematics teaching, particularly setting, closed teaching and rapidly paced lessons that disadvantaged a large number of students, particularly girls. Conversely it was the 'progressive' features of Phoenix Park's approach that resulted in the students' enhanced confidence and mathematical competence in a range of situations.

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The teachers and students at 'Amber Hill' and 'Phoenix Park' schools made this research study possible. I am profoundly grateful to the teachers at both schools, for their openness, their help and their friendship, and to the students for their honesty and trust.

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Chapter 1 An Introduction to the Study

1.1 Introduction

In 1935 a New Hampshire teacher conducted an experiment. He decided to abandon the teaching of formal arithmetic to his primary school classes and replace this with work on reading, discussion about number and estimation. When the children reached grade 6 he started to teach them formal arithmetic. At the end of grade 6 these children were doing as well in arithmetic as children who had been learning formal methods for three and a half years. To further convince people of this he would take visitors into classrooms and ask students to answer various problems involving the manipulation of numbers. Those without the early formal learning could make useful and sensible attempts, whereas those with the formal learning tried to select and apply rules, demonstrating a complete lack of understanding. They did not think about the problems and they produced non-sensical answers (Benezet, 1935a, 1935b, 1936). This is a story that will be echoed, sixty years on, in the results of this thesis, and it is a story that, I believe, was waiting to be retold.

1.2 Theoretical Perspectives

There is now an established concern within mathematics education that many people are unable to use the mathematics they learn at school in situations outside of the classroom context. In various research projects individuals have been observed using mathematics in real world situations such as street markets, factories and shops. In these 'real' settings individuals have rarely made use of any school learned mathematical methods or procedures. (Lave, Murtaugh, & de la Rocha, 1984; Masingila, 1993; Nunes, Schliemann, & Carraher, 1993). Lave (1988) compared adults' uses of mathematics in shopping and test situations that presented 'similar' mathematical demands. She found that the adults did not make use of their school-learned mathematics in shopping situations. She also found that the individuals did not regard the two mathematical situations as similar. Lave used this, and previous research findings (Lave 1982, 1986), to challenge the traditional conception of mathematics as an abstract and powerful tool that is easily transferred from one situation to another. She, and others in the field of situated cognition (Brown, Collins & Duguid, 1989; Young, 1993) have been instrumental in raising awareness of the importance of the situation, context or 'community of practice' (Lave & Wenger, 1991) in which mathematics is encountered, to the nature and form of individual actions.

Lave (1988) provided a powerful critique of those theories of learning transfer that suggest that mathematics is simply learned in school and then lifted out of the classroom and applied to new situations. She replaced notions of transfer with the idea that all learning is situated (Lave & Wenger, 1991, p30) and inherently linked to the situation or context in which it took place. One of the aims of this research study was to explore Lave's notion of situated learning and particularly to investigate those factors that appeared to influence school students when they encountered similar mathematical problems in various forms and contexts. Furthermore, I was particularly interested to discover whether different forms of teaching would create different forms of learning, that might influence the way in which students interacted with the demands of new and unusual situations. In order to do this I contrasted two very different learning environments and monitored the effects of these environments upon the mathematical understanding that students developed. My choice of mathematical environments was influenced by a number of factors that I describe below.

1.3 The Political Context

Various mathematics educators have suggested that students are unable to use school-learned methods and procedures because they do not fully understand them. This lack of understanding has been related to the way that mathematics is taught. Schoenfeld (1988), for example, argues that teaching students set methods and procedures that they rehearse in standard textbook questions encourages the development of procedural knowledge that is of limited use in non-school situations. These, and similar, arguments have contributed towards the growing support for open or process-based forms of mathematics. Supporters of process-based work argue that if students are given open-ended, practical and investigative work that requires them to make their own decisions, plan their own routes through tasks, choose methods, and apply their mathematical knowledge, the students will benefit in a number of ways. The reported benefits generally relate to increased enjoyment and understanding (Silver, 1994), to equality of opportunity (Burton, 1995), and even to enhanced 'transfer' (The Cognition and Technology Group at Vanderbilt, 1990). Research into the effectiveness of process-based mathematics teaching (see for example, Charles & Lester, 1984; Cobb, Wood, Yackel, Nicholls, Wheatley, Trigatti & Perlwitz, 1991; Cobb, Wood, Yackel & Perlwitz, 1992) is, however, limited, partly because process-based mathematical environments are extremely rare in schools.

In recent years in the U.K. there has been an official legitimisation of open forms of mathematics teaching, through the government-sponsored Cockcroft report of 1982

(Cockcroft, 1982) and then through the National Curriculum of 1989 and 1991 (DES, 1989, 1991), which made the teaching of process-based work statutory. In the United States, The National Council for Teachers of Mathematics (NCTM) also endorsed process-based approaches to mathematics in their NCTM Standards (1989). The U.K. support for open approaches to learning has, however, been viewed with considerable suspicion by the current Conservative government, who have mounted a firm opposition to all forms of open and problem solving approaches to learning. Part of this opposition included the reduction of GCSE coursework to a maximum of 20% and the imposition of national tests that only assess content knowledge. The government have also formed a set of policies, described by politicians and the media as 'back-to-basics' which encourage schools to emphasise 'sums, arithmetic and rules' at the expense of other areas of mathematics. Ball (1994) provides a useful summary of the conflict between proponents of what he has termed 'hard and 'soft' mathematics (Ball, 1994, p 89) and, more generally, the influence of the 'New Right' upon the school curriculum (Ball, 1993, p195). All of these developments have contributed towards the polarised position that now exists with many university educationists, on the one hand, espousing a firm commitment to a new, open, process-based form of school mathematics and the government, on the other, pressuring schools to move school mathematics back to a system of sums, rules and closed approaches. Schools frequently stand somewhere in between these two positions.

It is impossible to work within mathematics education and not be located somewhere within this debate. I began my research with both a critical perspective toward current government proposals and an awareness of a wide body of support for process based mathematics. At the end of my research I find this perspective relatively unchanged, largely because of the views and actions of the students reported within this study. It is an acknowledged fact that most qualitative research could be repeated by a different researcher with different results. This is part of the nature of research into complex social processes and probably applies to quantitative research to a greater extent than is widely acknowledged However, in this research study I found it difficult to believe that a different researcher, of any persuasion, could have left the classrooms of Amber Hill school[1] and listened to the appeals of the Amber Hill students without forming the opinion that traditional approaches to mathematics education disadvantage many students. Nor could another researcher have found it easy to look into the classrooms of Phoenix Park and listen to the reports of the students there without seeing the potential for something of greater value.

[1] All of the names of schools, teachers and students given in this study are pseudonyms.

1.4 The Research Study

In the face of opposing claims about the advantages of process-based work and back-to-basics approaches I chose to investigate, in detail, a process-based mathematical environment and to contrast this with a more typical content-based mathematical environment. A central part of this study included consideration of the influence of the two approaches upon the way in which students used mathematics in new and unusual situations. In particular I wanted to find out whether either approach encouraged students to develop a mathematical understanding that they would find useful in out-of-school situations. I was aware that a large body of research had shown the advantages of open approaches to mathematics teaching for students' performance on tests (Athappilly, Smidchens & Kofel, 1983; Resnick, 1990; Maher, 1991; Sigurdson & Olson, 1992; Keedy & Drmacich, 1994), but that there was very little research available in mathematics education that examined the nature and form of the classroom processes that contributed towards differential achievement. My aim therefore was not only to monitor the effectiveness of the different approaches, but to examine the way in which the different approaches influenced students. In order to achieve this I chose to perform in-depth, longitudinal and ethnographic (Eisenhart, 1988) studies of students working within two different schools.

I decided to conduct an ethnographic study because I wanted to retain the flexibility to design fieldwork and locate my interests in response to events within the two schools. This meant that the concerns of my study quickly expanded to include questions and issues that were not a part of my initial focus. Gender emerged as an important area in the early stages of my research, informed by a wide body of literature that has claimed that process based work enhances the attitude and achievement of girls (see, for example, Burton, 1986a, 1986b, 1995; Mura, 1995; Secada, Fennema & Adajian, 1995). The way in which students were grouped for their lessons also emerged as a less expected but very important influence upon the students' responses to mathematics teaching. The account that follows then is, in many ways, a general consideration of the teaching and learning of mathematics in two schools. In the following pages I will tell the stories of the students at Amber Hill and Phoenix Park, particularly focusing upon what it meant to be a student in the mathematics classrooms of these schools. I have centred this account upon the experiences and perspectives of the students; the motivations and influences of the teachers were a much smaller part of the study.

Bryk, Lee & Holland (1993) claim that there is no single factor that determines achievement and I became aware of the multiple influences upon my students' learning as the research progressed. I have tried to document and examine what I perceived to be the most important of these influences within this study. Given the range of different issues that became important to the research I decided against the use of a traditional literature review chapter. This was because such a chapter would have had to move between issues related to mathematics, situated cognition, transfer, gender and setting and there was no obvious or coherent way in which these issues could be linked. In addition, I felt that there would be many advantages to discussing the literature in the appropriate places as the story evolved.

A number of different theoretical standpoints could be used to discuss and interpret the findings from the two schools. Whilst being aware of the significance of different perspectives, such as constructivism and progressivism, I chose to locate the results of the research within a situated cognition framework. This framework acknowledges the influence of the students' knowledge, understanding, situation and context, upon the way in which students interact with different settings. At the beginning of the study my main aim was to consider whether 'transfer' could be enhanced by either of the school's approaches. As the study progressed I became more interested in the meaning of transfer, whether it existed at all and, if it did, what it looked like.

1.5 The Structure of the Thesis

After a description of the students and schools involved in the research in chapter 2, and a presentation of my methodology and research methods in chapter 3, I shall begin my account of the two schools. In chapter 4 I shall introduce the reader to Amber Hill school: a fairly traditional school that used a textbook approach for mathematics. This account will begin with a description of the school, the teachers and the main features of the school's mathematics approach. I shall then examine in more detail those characteristics of the school's approach that were particularly important to the students, in terms of their development of understanding and their perceptions about mathematics. Chapter 5 will present and describe Phoenix Park school in a similar way: outlining the distinctive characteristics of the school and examining the details of the school's unusual and 'progressive' mathematics approach.

In chapter 6 I shall depict the students' main responses to their mathematics teaching at the two schools. This chapter will show the impact that two very different approaches to mathematics had upon students' enjoyment of, engagement with and ideas about mathematics. In chapter 7 I shall then review all of the different indications of the students' understanding at the two schools. This chapter will be divided into sections and each section will describe a different form of mathematical assessment that the students undertook. The students' results on these assessments will be considered and compared and qualitative and quantitative measures will be combined to give an indication of the impact of the two approaches upon the students' development of knowledge and understanding. Chapter 8 will then provide a more reflective account, drawing upon the different forms of evidence presented. This chapter will mount a case for two very different forms of learning, based upon the students' own reflections on their use of mathematics. This chapter will also review notions of transfer and situated learning and consider the meaning of the different results of the research for emerging perspectives within the field of situated cognition.

In chapter 9 I shall consider the gender patterns that were evident in the two schools and show the varying responses of girls and boys to the different approaches used at Amber Hill and Phoenix Park. This account will give voice to the concerns of some of the students at the two schools who felt that they were disadvantaged by their mathematics teaching. I shall then use the reflections and preferences of the students to support and challenge different positions within the field of psychology and education. In chapter 10 I will show that the practice of setting students for mathematics had a significant impact upon the students' attitudes and understandings. The nature and extent of this impact varied according to the sex, 'ability', social class and confidence of different students. The effects that will be reported were not evident amongst the mixed ability students at Phoenix Park and reasons for these differences will be discussed.

In the final chapter I shall draw together the different results of the research, consider the way in which these inform existing theoretical perspectives and locate the results within a broad political perspective. This chapter will consider the many implications of different aspects of the study for 'progressive' and 'back-to-basics' approaches to education.

Chapter 2 The Schools and The Students

2.1 Introduction

The schools and the students within this research study will be considered in some depth in chapters 3 to 11. The aim of this chapter is to provide a brief overview of both the schools and the groups of students involved, which will serve as a general background to the chapters that follow.

2.2 The Two Schools

Amber Hill school is a relatively large, 11-18, grant maintained comprehensive school, with approximately 1200 students on roll. The mathematics department teach mathematics using the SMP 11-16 scheme. The school is fairly traditional and it is located in a largely white, working class area.

Phoenix Park is a smaller, 13-18 comprehensive school, with approximately 600 students on roll. The school is unusually 'progressive' and the mathematics department teach mathematics using open-ended projects. The school is also located in a largely white, working class area. More detail will be provided on the two schools in chapters 4 and 5

2.3 The Students

In each school I performed a longitudinal cohort analysis of a year group of students. I began to monitor the students when they started year 9 and observed the students' lessons, conducted interviews and gave out various different assessments, over a three year period until the students left at the end of year 11. At Amber Hill school there were approximately 220 students in my case study year group, at Phoenix Park there were approximately 110 students. In years 7 and 8 both sets of students were taught mathematics using the SMP 11-16 scheme. The Amber Hill students were taught mathematics at Amber Hill school in years 7 and 8, the Phoenix Park students all attended middle schools at this time. All of the middle schools taught mathematics using the SMP scheme. There were no significant differences between the 'ability', social economic status, ethnicity or gender of the students at the two schools at the start of the research period.

2.3.1 Ability measures

At the beginning of year 9 both schools administered NFER tests to the two case study year groups. The schools did not use the same test, Amber Hill used the 'NFER mathematics 12' test and Phoenix Park the 'NFER numeracy' test. NFER provide national data for the results of both of these tests taken by children of the same age. Figure 2.1 and table 2.1 below show the Z-scores of the students at the two schools, standardised to national means and standard deviations. These results show that 75% of Amber Hill students and 76% of Phoenix Park students were below the national average for the examinations. There were no significant differences between the attainment of the students at the two schools on these tests.

Figure 2.1 Standardised NFER scores for Amber Hill & Phoenix Park students

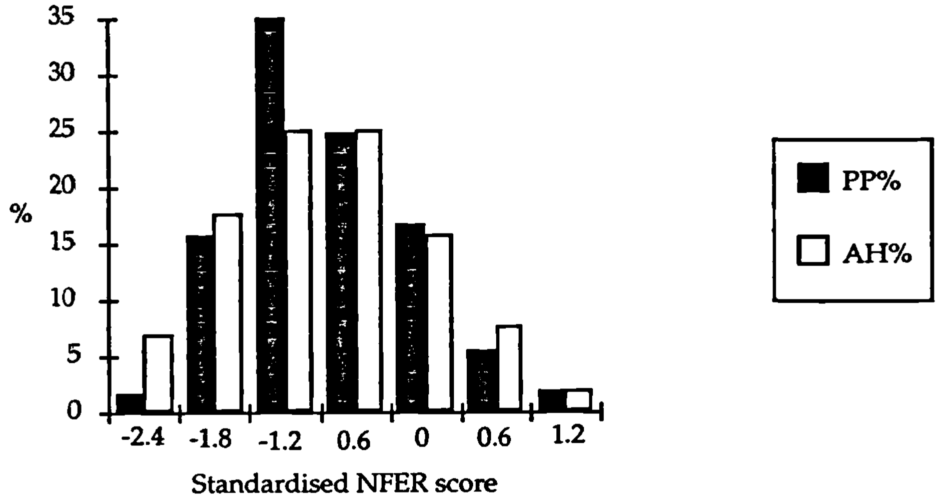


Table 2.1: Standardised NFER Scores

		-1 8 to-1.2	-1.2 to -0.6	-0.6 to 0	0 to 0.6	0.6 to 1.2	1.2+	total
n	AH	40	40	40	25	12	3	160
	PP	18	38	27	18	6	2	109
%	AH	25	25	25	16	8	2	
	PP	17	35	25	17	6	2	

$\chi^2 = 4.69$, d.f. = 4, $p < 0.50$, performed on collapsed table with the last two columns combined.

2.3.2 Socio-economic status

When the students were in year 11 they completed a questionnaire in which they were asked to describe the jobs of any adults they lived with. Approximately 60% of each cohort were in school to complete these questionnaires, other students were 'studying' at home. An analysis of social economic status, derived from fathers' occupations, shows that there were no significant differences between the students in the two schools who completed the questionnaires.

Table 2.2: Classification of Fathers' Occupations

		profe-ssional	interm-ediate	skilled non manual	skilled manual	partly skilled	unskil-led	house work	unem-ployed	total
		1	2	3	4	5	6	hw	un	
n	AH	5	21	13	64	15	5	4	1	128
	PP	1	4	9	37	9	7	1	1	69
%	AH	3.9	16.4	10.2	50.0	11.7	3.9	3.1	0 8	
	PP	1.5	5.8	13.0	53.6	13.0	10.1	1.5	1.5	

Ref: Office of Population Censuses & Surveys (1980) *Classification of Occupations 1980* London: HMSO

Table 2.3 : Ratios of working class: middle class students

	n		%	
	AH	PP	AH	PP
w/class	84	53	68	79
m/class	39	14	32	21
total	123	67		

(taking categories 1, 2 and 3 as middle class, 4, 5 and 6 as working class):
$\chi^2 = 2.4$, d.f. = 1, $p < 0.20$

The same data showed that 20% of Amber Hill students and 23% of Phoenix Park students lived within single parent families.

2.3.3 Ethnicity

Both schools kept a record of the 'ethnic origin' of their students. These are given in tables 2.4 and 2.5 below:

Table 2.4 Ethnic Origin

	English	Turkish Cypriot	Turkish	Italian	Greek Cypriot	Greek	Bengali	Caribbean/ W Indian	Somali/ Arabic
AH	202	2	5	9	4	2	1	6	1
PP	99	0	0	0	0	0	3	8	0

Table 2.5 Summary of Ethnic Origin

	English	Non-English
AH (n)	192	30
PP (n)	99	8
AH (%)	86	14
PP (%)	93	7

$\chi^2 = 2.58$, d.f. = 1, $p < 0.20$

2.3.4 Gender

At Amber Hill the year group was made up of 103 girls and 107 boys. At Phoenix Park there were 46 girls and 64 boys. This meant that girls made up 49% of the Amber Hill year group and 42% of the Phoenix Park year group.

Chapter 3 Methodology and Research Methods

3.1 Introduction

I shall begin this chapter with an overview of the different methods that made up the research study and the location of the different research methods in time. I shall then give a description of my methodology and the various philosophical and epistemological beliefs that influenced my research design. In the final part of the chapter I shall consider each of the different research methods I used in turn.

3.2 Research Overview

In order to contrast two different mathematical approaches I conducted ethnographic, three-year case studies (Eisenhart, 1988) of the mathematical environments in two schools. As part of these case studies I performed a longitudinal cohort analysis of a year group of students in each school as they moved from year 9 (age 13) to year 11 (age 16), monitoring the different experiences of the students over this three-year period. The two case studies included a variety of qualitative and quantitative methods which are set out below.

Table 3.1 Research methods overview

Time	Research Method	Subjects Involved
Year 9 term 1	Interviews	4 teachers from AH 3 teachers from PP
Year 9 term 1	7 contextualised short assessment questions	All year group in both schools n = 305
Year 9 term 2	Lesson observations 1 full week in each school	Approx 25 lessons in each school
Year 9 term 2	Questionnaires (including open & closed questions)	All year group in both schools n = 263
Year 9 term 3	Applied architectural activity and tests	Half of 4 groups in each school n = 104
Year 9 term 3	Lesson observations	Approx 5 lessons per school
Year 10 term 1	Lesson observations	Approx 10 lessons per school
Year 10 term 2	Long term learning tests	2 groups in each school n = 61
Year 10 term 2	Lesson observations 1 full week in each school	Approx 25 lessons per school
Year 10 term 3	7 contextualised short assessment questions	All year group in both schools n = 268
Year 10 term 3	Questionnaires (including open & closed questions)	Years 9, 10 and 11 in both schools n = 653
Year 10 term 3	Interviews	16 students from AH, 16 from PP
Year 10 term 3	Applied Flat Design activity and tests	4 groups in each school n = 188
Year 10 term 3	Lesson observations	Approx 10 lessons per school
Year 11 term 1	Lesson observations 1 full week in each school	Approx 25 lessons per school
Year 11 term 2	Interviews	24 students from AH, 20 from PP
Year 11 term 2	Questionnaires (closed responses only)	All year group in both schools n = 202
Year 11 term 2	Interviews	3 teachers from each school
Year 11 term 2	Lesson observations	Approx 5 lessons per school
Year 11 term 3	Analysis of GCSE answers	All GCSE entrants in each school n = 290

3.3 The Students Involved

The overall aim of my research study was to monitor the experiences of a year group of students as they moved from year 9 to year 11, but constraints of time meant that some of my research methods needed to be focused upon particular groups of students within the year groups. For example, my lesson observations, interviews and applied assessments could not be conducted with all of the mathematics groups in each year because of the time required by these methods. However, student questionnaires and short context assessments were given to all of the year groups in each school and my analyses of GCSE responses concerned all of the GCSE entrants, which was the majority of the year groups in each school.

At Amber Hill the year group was divided into eight mathematics sets (1-8) and the eight groups were all taught mathematics at the same time. This meant that in one day's visit to Amber Hill I could only observe up to one mathematics lesson with my case study cohort. I decided that it would not be productive to split my time between the eight mathematics groups, and chose, at an early point in the study, to focus upon sets 1-4. This decision was not made because I was particularly interested in 'high ability' students. The decision was made, mainly because the head of mathematics was most comfortable with me visiting these groups and partly because the students in sets 1-4 demonstrated some interesting patterns of performance in the first assessment activity I gave them. I therefore decided that most, but not all of my lesson observations, for my case study cohort, would be of sets 1 to 4, as would my interviews and the applied assessments the students undertook. In my observations of other year groups at Amber Hill I observed students in the full range of sets (1-8).

At Phoenix Park there were only five groups in my case study year group, these were taught mathematics at different times in mixed ability groups. In one visit to Phoenix Park I could watch up to three of my case study cohort lessons. This meant that at Phoenix Park I did not need to focus my methods upon particular groups. My lesson observations, interviews and assessments involved all of the five groups. When I was not observing lessons with my case-study cohort, I watched lessons in other year groups.

The 'samples' of students I worked with for some of the time were not therefore of a similar 'ability' at the two schools. The Phoenix Park students were from mixed ability groups and the Amber Hill students were from the top half of the school s 'ability' range. However, I was not too concerned about this because the aim of my study was not to monitor matched samples of students but to understand the factors that influenced the understanding of different students, through in-depth observations, interviews and assessments.

3.4 Methodology

3.4.1 Overview

I chose to combine a variety of different research strategies and techniques within this study, partly because of a belief that qualitative and quantitative techniques are not only compatible, but highly commensurable. Louis (1982) provides a useful account of the advantages of multi-method studies and the way in which quantitative and qualitative methods can be used to strengthen the validity of studies. I also used a number of different techniques in an attempt to represent what Ball (1996) has termed the 'mobile, complex, ad hoc, messy and fleeting qualities of lived experience' (1996 p 6). Ball (1996) and Miles (1982) both warn of the danger of reducing the complexity of experience and striving towards a theory that it 'all makes sense' (Miles, 1982 p126). In analysing the practices of two schools I did not wish to provide a definitive explanation of events, but a way of thinking that raised issues and questions about various features of school life. To this end, my research design was governed by the need to view events from a number of different perspectives and conceptualise factors such as enjoyment or understanding in different ways.

To understand the students' experiences of mathematics, I observed approximately 100 lessons in each school, usually taking the role of a participant observer (Kluckhohn, 1940; Eisenhart, 1988). I interviewed 32 students in year 10 and 44 students in year 11; I analysed comments elicited from students and teachers about classroom events (Beynon, 1985); I gave questionnaires to all of the students in my case study year groups each year; I interviewed teachers at the start and end of the research and I collected an assortment of background documentation. These methods, particularly the lesson observations and student interviews, enabled me to develop an understanding of the students' experiences and to begin to view the world of school mathematics from the students' perspectives (Hammersley, 1992). In order to locate the students' perspectives within a broad understanding of the two schools I also spent time 'hanging out' (Delamont, 1984) in the staffrooms and the corridors of the schools, I socialised with staff and I tried to develop a sense of the two schools in as many ways as possible.

In addition to these methods, I gave the students various assessments during the three-year period. Most of these I designed myself but I was also given permission to visit the examination boards used by the two schools and conduct a detailed examination of the students' GCSE examination responses. The various assessment activities and questions I used during the three years involved individual and group work, written and practical work. All aspects of the study, including my analyses of the students' environments and their understanding, drew upon qualitative and quantitative methods. For example, in an attempt to recognise the complexity of understanding I considered the students' responses to assessment activities and questions but I also considered their work in class, their behaviour in lessons and their comments in questionnaires and interviews. All of the research methods employed within the study were used to inform each other in a continual process of interaction and re-analysis (Huberman & Crandall, 1982).

My commitment to qualitative methods derived from a belief that real insight into the reasons that students succeed and fail in classroom situations is only achievable though lengthy, in-depth studies of students in their own environments. The time I spent in the classrooms of the students over the three years and my conversations with students and teachers enabled me to develop an understanding of the students' perspectives, as well as an insight into the events of their lives, which would not have been possible without the use of these qualitative methods.

I chose to adopt an ethnographic framework in order that I would have the flexibility to respond to the changing nature of events within the schools as and when they happened (Finch, 1984). This meant that the focus of my work was informed by the results of ongoing fieldwork and appropriate research methods were incorporated into the research design at different times. My initial research design included lesson observations, interviews, and applied assessments but long-term assessments, time-on-task data and GCSE analyses were added in response to events within the schools. The content of my interviews, questionnaires, lesson observations and assessments were also influenced by the ongoing process of data collection.

The various quantitative techniques I employed, such as student questionnaires, time on task data and large-scale assessments fitted well with the qualitative methods within the study, mainly because I regarded each of the methods chosen as a way of providing a different perspective on events. In making use of quantitative methods I did not adopt a positivist stance (Cohen, 1990), regarding the data as a set of indubitable facts demonstrating particular relations. Instead I viewed this data as a useful and informative way of providing a wider insight into a complex series of relations. I, similarly, did not regard qualitative methods as unproblematic or without limitation.

Where possible I used the different methods to support each other at different stages in the study.

I designed a longitudinal cohort study of the same students over a three year period, because I wanted to consider the changing nature of students' experiences over time and acknowledge the interrelationship of temporal and spatial events.

Agar (1986) defines the action of ethnographers as setting out to show 'how social action in one world makes sense from the point of view of another' (Agar, 1986, p 12) and many other qualitative researchers have forwarded this notion of 'seeing through the eyes of' (Bryman, 1988, pp 61-69) the respondent. The aim of my research was to observe and analyse the factors that influenced students' learning of mathematics and this involved understanding the world of school and school mathematics from the perspective of the students. During my three years of work in the schools I strove to view school mathematics as the students viewed it, to understand why they liked it when they did and disliked it at other times and to give voice to their concerns and feelings about the learning of mathematics. My intention in doing so was to gain insight into the way understanding was developed and to explore the many influences that shaped the development of students' ideas. These perspectives were also informed by the views and opinions of teachers which I gathered from interviews and conversations with staff that took place within and outside of school.

3.4.2 The development of grounded theory

The aim of my research was to contrast the effectiveness of two mathematical environments. I did not begin this work with a set of pre-conceived notions or hypotheses about the way in which the different environments would influence the learning of students, but I did begin the research with a set of perspectives and positions. These, inevitably, influenced the way in which I understood events in the field as well as the 'animating questions' (Silverman, 1993) that I formed. However, whilst I was in the classrooms of the two schools I was concerned to let the issues that were important to the two schools emerge. In order to encourage this I adopted a rigorous model of theory development and extensive use of triangulation.

Silverman (1993) distinguishes between positivist and interpretative social science by saying that the first is concerned with hypothesis testing, the second with hypothesis generation. Glaser and Strauss have developed a model of generating hypotheses through 'grounded theory' (Glaser & Strauss 1967): theory that is discovered from systematically obtained and analysed data. Although I did not set out to follow Glaser and Strauss' model at the outset of my research, when I discovered their writing it did describe very well the enterprise I had begun. Like Glaser and Strauss I was sure that if I spent time in classrooms and recorded what I saw, certain theories would emerge from the data and these theories would be more consonant with the realities of the situation than any theory I could have imposed from the beginning of the research.

The theories described in the chapters that follow represent the issues that emerged from the data collected in the two school settings. This emergence of theory, in preference to the use of an established or pre-formulated theory, does not mean that it was loosely formed or conceptualised. Emergent theories are achieved through a rigorous process of coding, concept formation, hypothesis generation and hypothesis testing. The important distinction between emergent and imposed theory concerns the fit with the settings being described. Because emergent theory is discovered, developed and analysed through a process of data collection, the issues that it represents should be those that are relevant to the area being studied. Strauss & Corbin (1990) describe grounded theory by saying that 'one does not begin with a theory then prove it. Rather, one begins with an area of study and what is relevant to that area is allowed to emerge' (1990 p 23).

The collection, coding and analysis of data took place as part of a continual process. Data collection waves were staggered, starting with initial field studies, followed by coding and analysis of data, a survey wave, a confirmatory field study, assessment of students, a re analysis of data, interviews with staff and students and so on. I coded, analysed and reformed ideas after each successive wave, in this way I progressively focused my ideas and used my analyses of events in the field to inform future research ideas. All of my fieldnotes and interviews were analysed through a process of open coding (Strauss & Corbin, 1990). This enabled the emergence of open codes in the first instance and core categories in more summative stages. I started coding interviews and lesson transcripts using codes that seemed to fit the data, in later stages I returned to these codes and developed and refined them. I would then compare and re-code examples of events using comparative analysis. In this way incidents were compared with other incidents and as many differences and similarities as possible analysed. When I became confident in the stability of different codes I moved to a stage of concept formation, combining different codes and using the different concepts as a way of integrating, explaining and analysing data. In appendix 2 I give an example of a coded interview. Appendix 3 presents the different interview codes I used at different stages in the research.

Strauss & Corbin (1990) talk about two analytic procedures which are basic to the coding process 'the first pertains to the making of comparisons, the other to the asking of questions' (Strauss & Corbin, 1990, p 62). In the forming of concepts and theories I continually asked questions of my data and looked for instances which answered these questions and supported or negated emerging theories. In the final stages of forming accounts of my two schools I deviated from Glaser and Strauss' model by stepping back from my interview and fieldnote codes and taking a wider perspective. This allowed me to consider the analyses of fieldnotes, interviews and questionnaires and write about the issues that all three sources suggested were important. The theories that I have proposed represent the result of overriding and integrating conceptualisations of events and influences in the schools. I did not write accounts that were based upon the codes developed from the different sets of data but I used the codes as entry points to my data, as a way of dividing and organising data. It was the process of coding that was essential in forming these conceptions, rather than the actual codes that resulted from each analysis.

A major strategy that Glaser and Strauss emphasise for furthering the discovery of grounded theory is comparative analysis. They assert that comparative analysis brings out the distinctive elements of social settings and I certainly found this to be true in my comparisons of the two schools. With all of the ideas I formed, the existence of a comparative source sharpened and crystallised the significance of emerging concepts. This occurred whether the concept was absent in the second school or present in different forms or quantities. The source of comparison also gave significance to concepts present in one of the schools which I may not have realised had they not been absent or present in a different form in the other school.

In my description of the two schools I have used the same, broad headings to organise events but the structure and detail within these headings varies between the two schools. This is because I have chosen to discuss the issues that emerged from the individual schools and these were not the same issues in each school. I believed that an account based upon issues which emerged as important would be more true to the data and to the spirit of ethnographic enquiry than accounts based upon matching headings and frameworks.

3.4.3 Triangulation

Triangulation was an essential part of my study and the most important source of validation of my emerging theories. The existence of multiple forms of data within my study meant that I was able to compare different forms of data in order to affirm or negate emerging ideas. The theories proposed in the chapters that follow have generally resulted from the triangulation of three or four sources of data. I have also used the same, as well as different, sources of data to triangulate viewpoints. For example, in Amber Hill school I observed in lesson observations that lessons were very similar to each other, in interviews the students complained about the similarity of lessons and in questionnaires students wrote about the lessons being too similar. At another point in the questionnaire students were asked to name their favourite lesson and the majority of students chose the same lesson. This I also took as an indication that lessons were rarely unusual or distinguishable. In triangulating this concept of similarity I was able to draw upon three different forms of data collection as well as two different sections of one data collecting instrument. Jick (1983) refers to these forms of validation as 'within method' and 'between method' triangulation.

Two other forms of triangulation, described by Smith & Robbins (1982), have also been used in the study. One has involved comparing the reports of events given by different respondents to check their consistency, the other has involved comparing events and behaviours over time. It is not always appropriate to reject ideas if they do not fulfil these criteria as respondents would be expected to have different viewpoints from each other and to vary their views over time, but when respondents have consistently supported each other in the notions they described this has added weight to my emerging theories. I have used my various forms of data collection in a continual, recurrent process of triangulation throughout the research. This has involved both within and between method triangulation (Jick ,1983) and within and across time / respondent triangulation (Smith & Robbins, 1982).

3.4.4 Respondent validation

In investigating the various influences upon the development of students' understanding I have tried to conceptualise school mathematics from the point of view of the students who experienced it. My analysis of the two environments is therefore taken from the perspective of the students and I have not attempted to analyse the teachers in a similar depth, nor have I represented their concerns to a similar extent. I do not see this as a limitation of the study, because an analysis of the teachers' concerns and motives in choosing to teach in the way that they did would have required a bigger research project. It did however mean that respondent validation was impossible because of practical, ethical and intellectual considerations, some of which I describe below.

Asking the teachers to read and give feedback on my representation of the students' views of mathematics would not have served the purpose of respondent validation. This is mainly because the teachers were not the respondents but even if we set this fact to one side, the teachers often appeared to have relatively little idea about the way in which the students viewed mathematics teaching. An affirmation or denial of the representation of students' views from the teachers would not therefore have served to validate or invalidate the perspectives offered. The problems attached to student validation were more complex, but the main disadvantage I envisaged concerned the ethics of the process. Some of the students in the study had very negative views about school mathematics. In my analysis of their situations I used a variety of forms of data to represent what I believed to be going wrong for the students. I felt sure that the students would have read these reports and agreed with my representation of their perspectives but I was concerned that, as an adult, I would not only be reporting upon their concerns but legitimising them. This legitimation would probably have led to the students feeling even more aggrieved about their mathematics education which did not seem to be an acceptable outcome of the research.

Focusing the study upon the perspectives of the students has meant that I have had to rely upon multiple forms of data collection and triangulation in order to validate my interpretations of the students' perspectives.

3.5 Research Methods

3.5.1 Lesson observations

I commenced my fieldwork with a small amount of knowledge about the schools' mathematical approaches, having been acquainted with the two heads of department each for about a year. My observations were spread out over the period of three years, sometimes taking place in continuous, intensive blocks, at other times during opportune visits lasting a day or less. In each year of the study I spent a week in each school undergoing intensive periods of observation and interviewing. I supplemented these weeks with numerous one or two day visits throughout each year. In total I observed approximately one hundred lessons in each school, each lesson was one hour long. The majority of my lesson observations took place in the classes of my case study cohort. In Phoenix Park I shared my time equally between the five mixed ability groups. In Amber Hill I shared my time equally between sets 1 - 4, with some occasional observations of sets 5-8.

When I visited the schools I almost always stayed for a whole day, which gave me time to observe different cohorts. I generally concentrated upon years 9, 10 and 11 in both schools, but I occasionally watched or helped out with lessons in years 7 and 8 in Amber Hill. On a number of my visits to Amber Hill I taught classes, as cover for teachers who were absent on that day, but I chose never to teach any of the classes in my case study cohort.

In my early lesson observations I had no prior notions about what I would look for, but concentrated upon collecting detailed descriptions of everything I saw or heard in the classroom. I began, always, by drawing a plan of the room and all of its occupants and then wrote down everything that was said by the teacher to the class, I also recorded as many of the teacher-student and student-student interactions as I could, including questions asked, answers given, complaints, asides and jokes. I watched the behaviour of students, their movements, postures and mathematical and non-mathematical activities. At the end of each lesson I would always have several pages of notes which I typed up each evening, adding other memories and comments of events as I did so.

Within the classroom my role could most easily be defined as a participant observer (Kluckhohn, 1940; Eisenhart, 1988) but even within lessons I varied in the degree to which I used and identified with structured and unstructured participatory techniques. During some lessons and during some parts of lessons I walked around and helped students and was perceived by the students as another teacher in the room. At other times I was more distant from the events of the room, for example, standing at the back recording the number of students who were working or answering questions. At the start of my research I experimented with an observation schedule, which I designed, but I quickly abandoned this as I found it to be too constraining. I felt able to present a much more detailed and accurate picture of classroom events using my own notes.

For the majority of my observations throughout the research study I followed the same pattern. I would start the lesson by watching and recording events, after ten or more minutes I would then wander around and interact with the students. I frequently used these interactions to further my knowledge of particular students' responses to mathematics. I often talked to students about what they were doing, I asked them what they understood the work to be about and how they felt about the work. Invariably as I walked around the room I would be asked for help, which I always gave. Most of the students in my case study groups were aware of my reason for being in their classrooms, they knew that I was doing research into their school's teaching approach and that I was from London University, they also knew that they could get help from me about mathematics if they wanted to.

I found my lesson observations invaluable, not only because they allowed me to keep a record of events in the two schools but because I was able to gain access to the students' perceptions about events in the schools as and when they happened.

3.5.2 Student interviews

In the second and third year of the study, when the students were in years 10 and 11 respectively, I interviewed at least four students from four case study groups at each school. In year 10 I interviewed exactly four students from four groups at each school, a total of 32 students. In year 11 I interviewed more than four students in some of the groups as there were more than four students that were of particular interest to me. In year 11 I also interviewed four students from set 7 of Amber Hill, a total of 44 students.

For the year 10 interviews I asked teachers to select students for me, based upon my request for students who would talk and feel comfortable in an interview situation. In year 11 I chose the students myself using more stringent criteria. These involved how well the students were doing at school (based upon their NFER entry scores and their positions in the groups they were in) and their attitudes towards mathematics (based upon questionnaire responses in years 9 and 10). In this way I was able to interview positive, successful students; negative, unsuccessful students; students who were underachieving and students who had been relatively successful at school, compared to their entry scores. In the year 10 and year 11 interviews I asked the students their views about school mathematics and then tried to find out why and how they had come by these views. The important difference between the year 10 and 11 interviews was that in year 11 I was able to interview students who represented a range of different perspectives. The interviews did not, in either case, offer a means of sampling opinions at the two schools. Their purpose was to increase my understanding of the students' experiences and to gain some insight into the ways in which different students developed different perceptions and understandings of school mathematics.

I approached my interviews with the year 10 students with a list of set questions but I followed up individual answers and, where I could, drew students into conversation about their ideas. In year 11 my interviews were more open than in year 10, I still used a list of questions but when students stopped talking I would talk to them about the issues that they had just raised and lead these into related questions. In this more open form of interviewing I still covered the same questions, but in an order dictated by the students. When our conversations came to a natural end I checked that all of my questions had been covered, and asked students any question that had not been asked. Measor (1985) has talked about the need for interviewers to be 'critically aware' of respondent's answers (1985 p 6), not only in order to build good rapport, which aids the interviewing process, but in order to understand the respondent's intents and meanings. In this way interviewers will be alert to 'pointers' which may be critical in understanding what is being said. I found that it was essential to maintain this 'critical awareness' during interviews and although I strove to do so, there were many times that I read through transcripts after interviews and wished that I had followed up more of the students comments that, at the time I let pass. Ely (1991) distinguishes between ethnographic and non-ethnographic interviews through the degree of structure which is negotiable. She asserts that ethnographic interviews are ethnographic, not because they are unstructured, as all interviews have a structure, but because the structure is shaped during the process of the interview, rather than predetermined from the start. From this definition I would describe my interviews as semi-structured and ethnographic.

I always interviewed students in pairs in order to make them more relaxed. This seemed to be a good strategy because I found the students to be incredibly relaxed, open and honest in almost every interview I conducted. They rarely appeared to agree with each other for the sake of it and they never seemed to worry about giving honest views of their schools and teachers. I always started the interviews by saying that they would be completely confidential and I would not be relaying students' opinions to the teachers. Even so I was often surprised by the open way in which students discussed their lessons and teachers. The students seemed to view me as an ally of theirs, rather than a friend of the teachers, even though they often saw me walking around the school talking with the teachers. In all but one of my interviews I interviewed single sex pairs of students. I aimed to do this from the outset but one of my pairs happened to be mixed in the first round of interviews. In this interview the boy dominated the discussion and I did not interview any other girl - boy pairs. Student interviews generally lasted between 30 and 40 minutes. All interviews were taped and transcribed. The student interview questions used in years 10 and 11 are given in appendix 28.

3.5.3 Teacher interviews

Each of the teachers of my case study groups, four teachers at Amber Hill, three at Phoenix Park were interviewed at the beginning of the research. At this time I talked to the teachers about a range of issues related to their teaching and their preferences for ways of working. These interviews were fairly structured, I worked through a set of questions which the teachers responded to, although I did also draw teachers into conversation about issues that seemed important to them. Each of these interviews took between approximately 40 minutes and an hour. At the end of the research I interviewed three teachers from each school again. In these interviews I talked to the teachers about some of the results of the research and asked their opinion about them and we generally had more open and relaxed conversations about events in the two schools. These interviews lasted for approximately 40 minutes. All of the teacher interviews were taped and transcribed. The teacher interview questions are given in appendix 28.

3.5.4 Elicited comments and key informants

In addition to my interviews I collected a lot of information about events in the schools through conversations with teachers in the staffroom, their classrooms after lessons, during telephone conversations and during social occasions. I inevitably formed bonds with teachers in both of the schools that, without doubt, increased the range and depth of my understanding of the schools. In both of the schools I formed relationships with teachers that would place them as my key informants (Burgess, 1988). In Amber Hill school the teacher with whom I spent most of my time, and with whom I had most conversations about my research was a teacher of one of my case study groups who also happened to be the head of the case study cohort year group. Hilary Neville's position as head of year meant that she was able to give me access to data such as the students' end of term reports and records on home backgrounds. It also meant that she was privy to a lot of information about the students that she always seemed happy to pass on to me and which I found extremely useful. Whenever I arrived in the school Hilary would always rush to get me a cup of coffee and find me a seat next to her in the staffroom. The other teacher with whom I had a lot of contact at the school was the head of mathematics, Tim Langdon. He would often telephone me and ask me if I wanted any help with anything and he was always keen to support my research in any way that he could. On many occasions Hilary and Tim almost seemed to be competing with each other for my attention and at later stages in the research I had to be careful not to offend either of them by, for example, mentioning to one of them, but not the other, that I would be coming into school. The most likely reason that I could think of for their responsiveness to me was that they liked having a school visitor, a visitor who knew enough about the school to be able to listen to their complaints and stories but who was not a member of staff, with their own issues and concerns to discuss.

At Phoenix Park the teachers were very different in their reactions to me, all three of my case study teachers were considerably more laid back with a laissez-faire approach to my work. They would chat to me when I was in school but they never showed any signs of trying to impress me in the way that the Amber Hill teachers did. Between the three mathematics teachers in the department I formed the strongest bonds with Rosie Thomas and Jim Cresswell. This was probably because Rosie was the only woman in the department and at the start of my research she was new and finding her feet and Jim was quite interested in my research. The head of department, Martin, would have been an obvious key informant but I did not spend that much time with him. During my research I had very interesting conversations with all of my key informants about events relating to the schools and my research. The key informants, in both schools, helped me to acquire a stock of implicit and background knowledge which, in turn, helped me to locate and make meaningful the individual data slices collected elsewhere.

Ely (1991) describes qualitative research as a recursive and personal process. I found this to be true and I always kept detailed notes, not only about my observations in schools, but about my feelings and perceptions of events and the meanings I constructed in relation to these events. Although I have chosen not to include an account of my own personal development (Jaworski, 1994) during the research as part of the thesis, such detail enabled me to look back at ideas I formed and understand exactly where they had come from. In both of my schools I felt that I became sufficiently immersed in the school's cultures to understand their relations without lo sing the critical, wide-angled perspective of the outsider (Guba & Lincoln, 1989).

3.5.5 Questionnaires

At the end of the students' year 9 I circulated a questionnaire to all of the two year groups which was fairly general, focusing upon the students' perceptions, descriptions and evaluations of school mathematics (see appendix 4). This was intended to provide an overall picture of the students' feelings about mathematics at this stage. This questionnaire combined open questions which gave the students blank spaces in which to write their responses with closed questions that had pre-coded Likert style response boxes. The questionnaire was completed by 160 Amber Hill students and 110 Phoenix Park students. The remaining students were absent on the days the questionnaires were administered.

The questionnaire given in year 10 (see appendix 5) was similar in style and content, but it was given to all of years 9, 10 and 11 at each school. I decided to do this in order that I might consider the views of my case study cohort alongside students in the year above and the year below them. In doing so I was able to gain insight into the typicality of my case study cohort's views, as well as the changing nature of students' views as they got older. I was then able to compare this data with the degree of change in my case study cohort's views as they got older. The year 10 questionnaire also contained some additional, more focused questions, prompted by my analysis of events over the year. This was completed by 163 year 10 Amber Hill students and 75 year 10 Phoenix Park students. One class group at Phoenix Park were not in school when I gave out this questionnaire and their teacher subsequently forgot to give it to them. The year 10 questionnaire was therefore only completed by 4 of the 5 Phoenix Park groups. In addition to my case study cohort, the questionnaire was completed by 157 students from year 9 and 100 students from year 11 at Amber Hill and 100 students from year 9 and 58 students from year 11 at Phoenix Park.

Both of these questionnaires were administered by class teachers who explained that the students were taking part in an important and confidential research exercise. Teachers were also asked to explain that the research was being conducted by an external researcher and teachers would not read students' responses. The students were given approximately fifteen minutes at the end of mathematics lessons in which to complete the questionnaires; this was sufficient for all students.

At the end of year 11 I gave the students a third questionnaire (see appendix 6). This was given to all of the students in year 11 at each school and it was made up of closed questions with pre-coded response boxes. This questionnaire also asked students about their enjoyment of mathematics and their perceptions of their mathematical understanding, but the majority of the questionnaire focused upon students' learning styles and their preferences for different forms of learning environment. The focus of the year 11 questionnaire evolved because of my interest in the relationship between student preferences for ways of working and their success in school.

At the end of the year 11 questionnaire I asked students to write down the jobs of any adults they lived with in order that I may construct an analysis of social economic status (see chapter 2). If their parents / guardians were unemployed I asked the students to write down the jobs they would 'normally' do. Because the students listed all of the adults they lived with I was also able to derive an indicator of the number of single parent families at each school. I explained to the students that this would all be confidential information and I was collecting it so that I could look at links between jobs and views about mathematics. Because of the sensitive nature of these questions I administered all of the year 11 questionnaires myself and talked t students about issues of which they were unsure. This questionnaire was completed by 129 year 11 students from Amber Hill and 73 year 11 students from Phoenix Park. The numbers taking the year 11 questionnaire were lower at both schools because the questionnaire was administered in the spring term, by which time some students had left and some students were staying at home to study, rather than going into school. All questionnaires, from years 9, 10 and 11, were pre-tested with students of similar ages at different schools.

All of the closed questionnaire results were analysed for overall patterns and for inter-relationships using chi-squared tests of significance where appropriate, and Fisher's exact test where numbers were small. Results for the questions which were open were coded and then analysed in a similar way. The results of the open sections of the year 9 questionnaire were recorded on systemic networks (Bliss, Monk & Ogborn,1983). The results of the year 9, year 10 and year 11 questionnaires are given in appendices 7, 8 and 9 respectively.

3.5.6 Time on task data

In response to my lesson observations I decided to collect information about the time students spent 'on task' in each of the schools. At three points during lesson observations - ten minutes into the lesson, the middle of the lesson and ten minutes before the end of the lesson - I counted the number of students who appeared to be working, who were definitely not working and who may or may not have been working. I continued to do this in lessons until the numbers I was recording had stabilised and additional lessons did not provide any new data. This amounted to approximately twelve lessons in each school. In order to triangulate the perspectives I gained from this and from my unstructured observations I also asked the students to say how long they thought they worked during a typical sixty minute mathematics lesson. Every student in the two year groups was asked to give this information, anonymously, by writing a number in minutes, on individual pieces of paper I gave out.

3.5.7 Short context questions

At the beginning of year 9 the students at Amber Hill and Phoenix Park were both beginning a new phase of their mathematics education. At this stage the immediate past history of the students in the two schools had been very similar. The short context questions were designed partly in order that I should gain some measure of the students' capability on numerical questions set in different contexts at the beginning of what represented a divergence in their mathematical pathways. The questions were also designed to provide a measure of the change in students' understanding as I planned to give them to the students in two successive years. There were four main requirements implicit in the design of the seven short context questi ns (i) they needed to assess the students' general capability on the content areas encountered (ii) they needed to give a measure of the students' developing understanding over time (iii) they needed to be broad enough to provide a suitable assessment for all of the students in the year groups (iv) they needed to assess the same mathematics in different contexts, because I wanted to observe the effects of contexts upon students' use of mathematics.

The seven questions all assessed aspects of number and they were taken from established books, schemes or research manuals. The contexts were chosen partly in order to provide stereotypical girl and boy friendly situations. The seven questions were given to the entire cohort of case study students at the beginning of their year 9 and the beginning of the research study. In the summer term of year 10, almost two years later, the same students took the same questions again with an additional two questions which were slightly more demanding. All of the questions from years 9 and 10 are given in appendix 10.

Students in both schools were given an hour to complete the question booklets. The booklets were compiled so that half of the students always took one of the pair of context questions first and the other half the other one of the pair. This enabled me to observe the effects of question order on students' responses. Students were asked to complete the questions alone and without the aid of calculators.

3.5.8 Applied assessment activities

The two applied assessment activities, given to students in years 9 and 10, were designed in order to provide students with the sort of mathematical challenge they may eventually face in the 'real world'. Because the activities were situated in classroom settings the results could never indicate what students would do in *real*, 'real world' situations. However, they did provide very useful indications of the way in which students approached tasks that differed from their normal school mathematics questions and activities. The constraints built into the design of the tasks also elicited important information about the way in which students chose and used mathematical methods. The students' responses to the applied assessment tasks were compared with responses to specifically designed short, written tests which assessed the same areas of mathematical content.

a) The architectural activity

In the summer of their year 9, approximately half of the students in the top four sets at Amber Hill and half of the students in four of the mixed ability groups at Phoenix Park were asked to take part in the architectural activity (see appendix 11). The NFER entry scores for the two groups of students who took part in the activity show that the students at Amber Hill were of a significantly higher 'ability' than the students from Phoenix Park (see appendix 12). This did not cause major problems however, because my main aim was not to compare overall performance at the two schools, but to compare each individual's performance on a test with their performance on an applied activity. Approximately two weeks prior to the activity all of the students in the eight groups involved took a short written test which assessed all of the mathematical content they would be required to use in the activity (see appendix 13). The content was of a comparable difficulty to that involved in the activity but each mathematical content area in the test was assessed through a separate, short question.

As part of the architectural activity students were given a small scale model of a house, a scale plan of the same house, a formula sheet, a task sheet, an extract from a council booklet on housing design and two report sheets to complete. Their task was to write a short report stating whether or not the proposed house passed the council's design rules. In order to do this students needed to locate appropriate information, take and use measurements and combine different areas of mathematics such as multiplication, division, area, volume, percentage, angle and measurement. The content in the activity was chosen as it had been taught to all of the students in all of the classes involved. Students had access to calculators and a formula sheet at all stages. Further detail is given on the architectural activity in chapter 7.

b) Planning a Flat

The 'Planning a Flat' activity (see appendix 14) was adapted from a GAIM (1988) activity of the same name. The activity and a set of questions which I designed to accompany it were given to complete classes. At Amber Hill these were the top four sets, at Phoenix Park they were four mixed ability classes. The Amber Hill students were, again, of a significantly higher ability, as measured on their NFER entry tests (see appendix 15). Students worked on the activity and accompanying questions over the period of two consecutive lessons, each lesson lasting one hour. Approximately one month before completing the activity and related questions the students were given a short written test which assessed all of the areas of mathematical content they would need to use (see appendix 16).

In the first lesson students were given the GAIM task based around an A3 plan of an empty basement flat. The plan showed only the external walls of the flat, along with windows and a front door. The students were asked to decide upon the intended owners of the flat and then decide upon appropriate rooms to put into the flat. Students then needed to draw rooms, doors and furniture onto the A3 plan using their knowledge of measurement and scale and attending to two building constraints that were given to them. In the second lesson students were given three questions to answer on area, estimation and angle, related to their flat designs.

Both the architectural activity and the planning a flat activities and questions were pre-tested with students of the same age in different schools.

3.5.9 Long-term learning questions

The design of the long-term questions was prompted by the research of Bassford (1988). He found that students who had learned about fractions in a diagnostic teaching programme performed significantly better twelve weeks after they had completed the work, than students who had learned the same mathematics through SMP 11-16 booklets, despite parity in performance immediately after the work was completed.

In a similar research design to that used by Bassford I chose two areas of work in each school and designed a test to assess the students on the work. The tests were designed to assess the learning that took place on a particular topic, in a similar style and format as the actual work. The tests were given to students immediately before they started the work, as soon as they had finished the work and approximately twenty four weeks after the work had been completed. On each of the three assessment occasions the students in each class took exactly the same test. These tests are given in appendix 17.

3.5.10 GCSE analysis

In the summer of their year 11 the majority of the year group in both schools took GCSE examinations. The schools used different examination boards but the questions set by the different boards were broadly equivalent and both boards provided students with most of the mathematical formulae they needed to use in the examination. After the examinations had been marked I was allowed to visit the two examination boards and take a record of all of the students' marks on all of the questions on the examinations. I had previously categorised each of the marks available on each examination paper as requiring either 'procedural' or 'conceptual' knowledge. I defined a procedural question as one that could be answered by the use of a standard learned procedure. A conceptual question was one that could not be answered from memory alone and involved a greater degree of thought. One of my supervisors re-coded all of the questions on two of the examination papers as either conceptual or procedural. This produced 95% agreement.

3.5.11 Background documentation

In order to gain a more general understanding of the schools I collected a variety of documentation including departmental handbooks, school prospectuses and student magazines. During my times spent in the classrooms and staffrooms I also copied various notices and displays from around the school. In addition to my own data collection instruments I also made use of the department's own assessments given to the students at various points during years 9, 10 and 11.

Chapter 4 Amber Hill School

4.1 An Overview of the School

4.1.1 Introduction

Amber Hill school is a mixed, 11-18, grant maintained comprehensive which is fairly large, with approximately 1200 students on roll. It is located in the main working class area of Fieldton, a large suburb of a major city. The majority of the students who attend the school are white and working class and the school is usually placed at or near to the bottom of Fieldton's LEA league table of twelve secondary schools.

Amber Hill school is located in a quiet, residential road, overlooked by two high rise blocks of flats in which many of the students live. There is a busy main road a few minutes walk away from the school which leads to Fieldton town centre. Amber Hill occupies a large single storey building, built in the 1930's. The low height of the building gives it a friendly, primary school look from the outside. Inside the school the reception area has a calm and respectable air, helped by the fact that it is separated from the rest of the school by a set of heavy double doors. The floors are carpeted in a sombre grey, a number of easy chairs have been placed by the secretary's window and a small tray of flowers lies above them. The secretary's window has an Amber Hill coat of arms above it and 'Welcome to Amber Hill' in large plastic letters. A stand contains a number of glossy leaflets and brochures, including the recently produced *Guide to Amber Hill School.* The walls display school achievements, photographs from sports days, school trips and musical events and a photograph of two students receiving a design and technology award. Iconographies of traditionalism are located throughout the reception area, presenting strong messages about the way in which the school is intended to be perceived. A glass dome has recently been built onto the outside wall of the school, leading to the reception area. Visitors to the school need to walk through the dome, which is filled with lavish and expensive plants. Gewirtz, Ball and Bowe (1995) talk about the increase in 'glossification' (1995, p127) of school imagery since the Education Reform Act and the implications of this for the educational provision of students. The glass dome was extremely expensive, it was paid for out of grant maintained funds and many of the staff resented the money spent upon it.

Amber Hill became grant maintained (GM) one year prior to the beginning of my research. This was largely due to the campaigning of the head teacher. This decision prompted a handful of staff to leave and many of the remainder to view subsequent changes to the school, such as the building of this dome, with measured quantities of cynicism. The head teacher was a particularly important and influential figure at Amber Hill. John Patram was the archetype of the 'authoritarian head' (Ball 1987 p 109), particularly in his attitude towards opposing views which were 'avoided, disabled or simply ignored' (1987 p109). The mathematics teachers reported that he imposed decisions upon staff, after statutory consultations which he ignored.

> The teachers think he's dictatorial, the departments think that about him too. You're given a job to do, but if you don't do what he wants - well he gets the governors' support and it all gets very personal. He's got rid of a lot of staff, he makes them redundant. He'll put pressure on staff to go - and if they're not strong they will go. (Hilary Neville, mathematics teacher.)

John Patram had an austere appearance, he was always dressed in a dark suit and wore a solemn expression. At break times he wandered the corridors shouting at students, the staff seemed as unwilling to bump into him as the students. He rarely visited the staffroom and never socialised with staff.

Partly as a result of the head teacher's influence and power, Amber Hill was unusually ordered and orderly. Students generally did as they were told, their behaviour governed by numerous enforced rules and a general school ethos which induced obedience and conformity. All students were required to wear a school uniform: trousers, shirts and ties for boys; tartan skirts, shirts and no ties for girls. The vast majority of students wore their uniform as the regulations required; teachers objected to those who did not, in a friendly but forceful manner. The annual school report institutionalised just one aspect of Amber Hill's attempts to encourage and capture an 'expressive order' (Bernstein 1966). Two boxes at the bottom of the report required the tutors to give the students a grade on their 'co-operation' and their 'wearing of school uniform'. The head clearly wanted to present the school as academic and respectable and he was successful in this aim, at least in terms of the general facade. Visitors walking around the corridors would see unusually quiet and calm classrooms, students sitting in rows or small groups, usually watching the board and generally being quiet or silent. When students were unhappy in lessons they tended towards withdrawal, in preference to disruptiveness. The corridors were mainly quiet and at break times the students walked in an orderly fashion between lessons. The students' lives at Amber Hill were, in many ways, structured, controlled and uniform.

4.1.2 The staff

There were seventy teaching staff at Amber Hill who were quite polarised in terms of age A large number of the staff had been at the school for ten years or more whilst a similar proportion were in their twenties and had been teaching for less than three years. The staff appeared to mix well although it was clearly difficult for such a large number of staff to have a coherent ethos. My perspective on the staff as a whole was also limited by the fact that few staff spent their non-contact time in the staff room, as I, and the mathematics department did. The remainder chose to stay within their subject domains. This tendency was indicative of teachers who fit within Bernstein's collection code (1971) and who have been socialised into strong subject loyalties.

The staff room was split into two main rooms, one for smokers, the other for non-smokers. The main core of the mathematics department always sat in the smoking section, which seemed to derive from the fact that two mathematics teachers smoked. The staff room was sparsely furnished with a few easy chairs, a few desks, a drinks machine and a notice board; there was no provision of food or drink at break times. The staffroom did not seem to be a particularly social place: few teachers visited it at break times, apart from the mathematics department who taught close by. Five of the mathematics department had commandeered their 'own' comfy chairs in which they always sat. The smoking section of the staffroom tended therefore to be an arena for complaints about various students' behaviour in mathematics lessons or incredulous reports about the number of mathematics booklets a student had completed.

The mathematics department had nine members, including one teacher who worked half time and one who taught mainly IT. Seven of the department had been at the school for between eight and eighteen years, two for three to four years. The head of department, Tim Langdon, was in his mid thirties and had been at the school for four years at the start of my research, he had a degree in mathematics. The rest of the department seemed to view Tim as the progressive one who kept them in line:

> Hilary: He gets all these ideas that we're meant to do, you know, like multiplying brackets out pictorially, but some of us, we just tell them the rules and then we have to rub it off the blackboard quickly if Tim comes along.

Tim's suggestions and gentle chidings were all taken in good hum ur, and the various staff seemed to enjoy their self selected roles, Tim as the one with the new ideas, the rest providing the voice of reason. Tim did not seem to me to be particularly progressive at all, although I was aware that he identified himself as such. Early on in our discussions Tim told me how much he liked going to the Association of Teachers of Mathematics (ATM) conferences because he enjoyed meetng people who thought in the same way as him and who had a "modern attitude" towards mathematics. Tim had not been to an ATM conference for many years, although I know that he attended two about six years ago (before his children were born). Tim believed in the Secondary Mathematics Project (SMP) scheme, which the school used in years 7 to 11. He regarded this to be an innovative scheme and the new publications that SMP issued from time to time made him feel that he was keeping abreast of the latest developments in mathematics education:

> SMP? - yeah some of it's rubbish and certainly on the A-level they got carried away, but they at least look at what is happening in maths, and try to bring new approaches in and try to re-jig what was actually in place. So if you want, you've got an evolving set of texts and, if, from my perception, maths is changing, the text needs to change, to culminate new ways of working, new maths - well, not necessarily new maths, but maths at the level of the school child. (Tim Langdon, head of mathematics.)

Tim was also vocal in his support of Attainment Target 1 of the national curriculum and open-ended work, but this played a minor and compartmentalised role in the department's scheme of work, which he designed. Tim had more progressive *ideas* than the rest of his department, but he did not seem to put these into action and his teaching was, in some ways, more traditional than that of the other teachers.

Tim was always friendly and amiable. He was also extremely conscientious and hard working and would go to any length to help me with my research, for example, organising interviews, planning which lessons I could see, sending me information and timetables. Tim always knew the 'right' things to say about mathematics education and always seemed keen to impress me. This had a double edged influence upon my research. It was helpful because Tim was so keen to help out and assist me in whatever I wanted to do in the school, but I was aware that Tim made every effort to present me with the best side of his and the department's teaching, what Goffman refers to as 'impression management' (Goffman, 1959, p203). The following extract is taken from my early observation notes when Tim and I were choosing a class for me to visit:

> Tim looks through the time-table saying 'Well, the choice is Ron, Mick, Alan or Pauline. So that's no choice really Pauline's a complete no no, Alan's a pain in the ass, Mick is very didactic and you won't hear the students say anything, so you might as well see Ron'.

In my first term in the school Tim was often doing practical activities with his groups when I watched them, which I found out from the students was very unusual. I learned to get around this from the second term onwards by giving Tim as little notice as possible about the lessons I would be visiting. Even so I was never 'allowed' to visit Alan or Pauline's lessons, the two mathematics teachers of whom Tim had a low opinion.

Tim did not have a good relationship with his second in department (Pauline), who was frequently absent from school. This was part of the reason that he valued Hilary Neville so much and the reason he often discussed departmental issues with her. Hilary was a mathematics teacher in the department and the head of year for my case study cohort, so she had a senior position in the school. Hilary always seemed pleased to have me around and we became friends during the research. Hilary was my key informant (Burgess, 1988) at the school and she was always willing to share departmental gossip with me and to provide me with an insight into the internal politics of the department. Hilary was in her forties and was both friendly and assertive with staff and students. She was also extremely committed and hard working and obviously cared a great deal about the students. The other staff seemed to respect her greatly. Hilary, who had an education degree in PE and mathematics, identified more as a mathematics teacher than as a year head. She always sat in the staffroom with the other mathematics teachers and talked about mathematics lessons, usually whilst smoking a cigarette. Students often came to the staff room to see her, which she never seemed to mind.

Leisel Thompson always sat on the edge of the ring of chairs where most of the mathematics department sat. She would listen to their jokey conversations but rarely join in, instead she would chat quietly with members of other departments. Leisel always seemed interested in my research and whilst most of the mathematics teachers seemed self conscious about what I may be discovering about them as teachers, Leisel seemed genuinely interested in research on different types of mathematics education. Leisel had a mathematics degree, she was in her late forties and she had been at the school for eighteen years.

Edward Losely was distinct from the rest of the department due to his age and his general liveliness about the school. At the start of my research he was a newly qualified teacher of about twenty-five years of age. He was always grinning and joking with various members of staff and he helped to organise the school's football and cricket teams. Edward was quite large and athletic looking and clearly enjoyed being 'one of the lads'. This extended to his lessons when he was often joking with boys in a 'laddish' way and referred to beer, pubs, football and cricket in the examples he chose to describe mathematical situations. Edward also had a mathematics degree

Tim, Hilary, Leisel and Edward were the four teachers of sets 1 to 4. The other five members of the mathematics department were aged between 40 and 60 and shared the belief that SMP was a progressive and useful innovation. The teachers had concerns about individual students' mathematical knowledge and understanding but they did not reveal any reservations about the SMP scheme. All of the teachers complained to Tim about having to do investigational work and open ended tasks but they did believe in the occasional use of these activities.

All of the mathematics teachers, Tim included, believed that the most efficient and effective way to teach mathematics was to impart knowledge of different mathematical procedures, using the blackboard, and then get students to practice these procedures in exercises. The teachers believed that if they explained mathematical methods clearly, the students would gain an understanding of them:

> I prefer to teach the whole group together, otherwise I don't think it gets embedded, a lot of the difficult stuff. I really feel they need, I dunno leadership, the old fashioned chalk and talk to make them understand. (Hilary Neville)

The teachers also believed that students needed to do a large number of similar exercises, because the act of repeating a procedure they had learned would make students remember it:

> The only thing wrong with the SMP books is they don't have enough repetition which, well, I know it's dead boring but that's the way it sinks in. (Edward Losely)

The teachers' belief in this didactic model of teaching meant that their main concern as teachers was to cover all of the necessary mathematical content:

> We've all done maths, so they've got the biggest resource standing in front of the class. And it's superb being able to - you've got the national curriculum basically and if you cover the national curriculum you're doing your job. (Edward Losely)

The teachers were aware that they needed to teach and assess attainment target 1 of the National Curriculum but they believed this to be taken care of because the students were given one open-ended activity to do in year 10 and one investigation to do in year 11. The distinct separation of the process and content areas of mathematics maintained within their approach is what Blum and Niss (1991) refer to as the 'separation approach', common in many schools (1991, p60).

The mathematics department all taught in the 'maths corridor', a long corridor which had eight mathematics classrooms on one side and windows looking out onto the playground on the other. The corridor was long and narrow with low ceilings and light blue painted walls. The walls were bare apart from a small cluster of posters and notices at one end of the corridor.

4.1.3 Mathematics teaching at Amber Hill

Amber Hill used the Secondary Mathematics Project (SMP) scheme in years 7 to 11. This meant that in years 7 and 8 the students worked through individualised SMP 11-16 booklets; in years 9 to 11 they moved to a more formal textbook approach. Students began year 7 in mixed ability classes and were setted into eight mathematics sets at Christmas of year 7. In years 7 and 8 students worked through the individualised booklets, at their own pace, with no class teaching from the front. In year 9 they moved to a more formal system of textbooks and class teaching. There was no departmental policy about the way in which classes should work in years 9 to 11 but all of the teachers adopted the same pedagogical approach. They explained methods from the blackboard at the front of the class for the first fifteen to twenty minutes of each lesson, they then set the students questions to work through from their SMP textbooks. Most of the teachers questioned students whilst lecturing from the blackboard. Teachers did not, generally, object to students talking quietly as they worked. Most students sat in pairs and they would work alone, usually stopping to check with their partner that they had got the same answer at the end of each question. All mathematics lessons were one hour long.

> JB: What do you do in a typical maths lesson?
> J: Well sir usually goes over the work we have to do before we do it. So he'll write on the board what we have to do and explain the questions and that and the rules, the basics of what we have to do in the work and then he'll tell us to get on with it.
> JB: From books?
> J: Yeah from books and if we need help he'll come along and help us.
> JB: And how long does he talk from the board and how long do you work from books?
> J: About half a lesson. (John, AH, year 10, set 1)

The students worked from textbooks in each and every lesson. When they completed a chapter, they would do the textbook 'review' which assessed the work in the chapter:

> A: It's always out of textbooks innit?

G: Yeah, we do a chapter, then we do a review and it's like that over and over again. (Alan & Gary, AH, year 11, set 3)

Lessons at Amber Hill were unusually ordered and controlled. Students were well behaved and it was rare to see teachers invoke any disciplinary procedures against students. When the teachers talked from the front of the room the students would sit in silence listening to them, watching the board and writing down what they were told. Students worked quietly through their exercises and confined any misbehaviour to chatting with their partners. In lesson observations I was repeatedly impressed by the motivation of the students. In a small quantitative assessment of their 'time on task' (Peterson and Swing, 1982) I recorded the number of students who were working ten minutes into, half way through and ten minutes before the end of each lesson. Observing eight lessons, each with approximately 30 students: 100%, 99% and 92% of the students appeared to be working at these three respective times. The first of these figures was particularly high because at this early point in lessons the students were always watching the teachers work through examples on the board.

The students wanted to do well in mathematics and believed it to be an extremely important subject. This motivation, combined with their compliant behaviour, meant that the teachers usually had captive audiences in lessons who were willing to do whatever the teachers told them. The mathematics teachers at Amber Hill had good relationships with students. None of the teachers were authoritarian, all of them were friendly and the students reported that they found them approachable and always willing to help.

4.2 Important Characteristics of the School's Approach

In the following account I will describe the important features of the school's approach. I have defined these characteristics as important because they appeared, to me, to have the greatest impact upon the way in which students formed their perceptions and understandings of mathematics.

4.2.1 Closed approach

At Amber Hill school students worked from textbooks almost all of the time and most of the questions in the textbook were short, procedural (Hiebert, 1986) and closed. Some more open or applied questions did feature at the end of exercises and in 'miscellaneous' exercises at the end of chapters, but when students encountered such questions the teachers would normally close them down. Doyle asserts that teachers avoid classroom conflicts by 'redefining or simplifying task demands' and 'softening accountability to reduced risk' (Doyle, 1988, p174). The Amber Hill teachers achieved this by breaking questions into small, atomistic parts and guiding students through any mathematical decision making. Some teachers isolated the more demanding questions in the chapters and put them up on the board prior to lessons. In other lessons teachers broke the problems down for students in one to one situations or, with the whole class when a problem caused difficulty. They would generally do this using what Doyle and Carter (1984) have referred to as 'extensive teacher prompting' (Doyle & Carter, 1984, p137).

The following fieldnotes were taken during a year 9 set 5 lesson with Tim Langdon:

> TL announces that he is going to put the 'problem' from the end of the chapter on the board. He draws:
>
> | | | | |
> |---|---|---|---|
> | Blagdon | 0730 | a | b |
> | Westerfield | c | 1045 | d |
> | Scaly Bridge | 0845 | 1120 | 1535 |
> | Laughton | 0935 | e | f |
> | New Harbour | g | h | 1640 |
>
> TL then comes over to me and says 'this is the classic problem with SMP, it gets them working down columns linearly or across and then suddenly there's a massive jump to this'. 'And they can't do it?' I ask 'well they can if you do this (he strokes my arm) and say "come on you can do it, you can do it, do this bit and then do that bit". After TL has put the problem on the board he gets all of the students to listen and then asks Gary, who Tim knows has worked out f), to explain how he got his answer. Gary mumbles 'you can see it takes one hour, no, 50 minutes to go from Scaly Bridge to Laughton so I done that, I added that onto Scaly Bridge and it come out 1625.' Whilst Gary is talking the other students look distracted and don't appear to be listening to him. TL says, 'good, which letter shall we work out next?' Tracey offers e), 'come on then Tracey', says TL, 'I'm not doing it' Tracey says. TL then asks, 'Well how long does it take to get from Scaly Bridge to Laughton?' 'no idea' Tracey says, 'Come on we've just heard how long!', someone else calls out '50 minutes', Tracey repeats this, 'OK' says TL, sounding exasperated, 'so what is 1120 plus 50 minutes?' 'Dunno' says Tracey then 'oh, hold on, it's 1210'. 'See you can do it' says TL. 'Did I get it right?' Tracey asks with surprise, TL says that she did 'oh cocker' says Tracey, pleased.

> TL moves through the problem asking different students similar small questions each time 'Well how long is it from here to here?' (pointing to two times) etc. TL asks Michael to do one of the letters, Michael says 'I can't do it' so TL leads him through it: 'How far did Leo say it was from here to here?' Michael trawls in his memory for the time, rather than trying to interpret the table, he gives the right answer, 'so how far is it from here to here?' TL continues. Eventually Michael gets to the answer and TL says 'wonderful, I thought you said you couldn't do it, have some confidence!'. TL continues with different students until all of the questions are completed. None of the students, even the last ones asked, attempt to get the answers without TL leading them through the problem step by step. (Year 9, set 5, Tim Langdon.)

In this example Tim encountered an SMP question that required more thought than normal. The mathematical demand was no more difficult than other questions, but the students needed to think about what to do in order to solve the problem. Tim responded to this by putting the question onto the board and leading the students through it. Tim effectively removed the thinking demand from the question and left students to subtract and add pairs of numbers. He did not even encourage students to think within the small isolated domains which he defined. For example, when Michael said he did not know how long it took to get from one destination to another Tim did not ask him how he could find out or encourage him to interpret the information on the board, he asked 'how far did Leo say it was?', urging him to recall the time which another pupil had given. Thus, even in potentially open situations, Tim created 'focused' environments (Walker and Adelman, 1975). He combined high definition questions which had one correct answer, with a closed sequencing of content, moving in 'tight, logical steps between one item and the next' (1975, p47). When all of the problems had been solved Tim seemed to feel a sense of achievement, even though the exercise highlighted, for me, the little that students were able to do.

The predominance of the teachers' tendency to redefine questions and narrow their scope was not only evident in relation to questions which were open, it was a more pervasive general tendency which seemed to form the basis of all mathematics instruction. In almost every lesson I watched, teachers responded to the students' inability to answer questions by offering them a multiple choice question, with one of two correct answers, for example 'well, is it 4 or 5?'. The students would select an answer and if this was right, the teachers moved on, 'so is it the length or the width?' and so it proceeded. If students selected the wrong answer the teachers would repeat it, using a disbelieving tone, which was an indication that the students should plump for the other answer. The following extract is taken from a year 11, set 3 lesson on trigonometry, taught by Hilary Neville:

HN says Yvonne, part b?, Yvonne says 'miss I can't do it', HN responds saying - 'well what is DC to the angle?, opposite or adjacent?', someone calls out 'opposite', HN continues 'and we've just found B, which was what?' someone offers 'adjacent', HN continues 'and opposite and adjacent give us what?' (pointing to some trig ratios on the board) someone offers 'tan', HN continues, 'so tan what?', there is silence, so HN says 'tan 1.5' then 'tan 1.5 gives us what?' someone puts this into their calculator and gives the answer '14'. HN says 'correct' and moves on to the next question. (Year 11, set 3, Hilary Neville)

Other research studies (see, for example, Barnes *et al*, 1969), have suggested that the tendency of mathematics teachers to ask closed questions with short factual answers which do not require any interpretation or reasoning, is not unusual. The teachers at Amber Hill rarely asked the students what they thought they needed to do, nor did they require them to place questions within a wider sphere of understanding. Instead paths were constructed which consisted entirely of short, structured questions and these paths formed the basis of much of the mathematics guidance at Amber Hill. When students asked for help with their questions, the teachers did not talk to them about what they were doing, they would give them a series of instructions taking them through the questions:

M: He says you do this to get that, you do this to get that and you go 'oh, right then'.
H: Yeah, he gives you the answer, you write the answer down and that's it. (Helen & Maria, AH, year 11, set 1)

The students believed that they received more help and structure than they wanted or needed in their lessons:

S: I think he goes through it too much, I think he should just let us get on with it and see what we can do, and then go through it, if we don't understand it. (Sacha, AH, year 11, set 4)

The teachers broke problems down for students and gave them lots of help because they believed that this would give them mathematical confidence and, ultimately, help them learn mathematics. These good intentions resulted in the students spending the majority of their time engaged with low risk, closed tasks (Doyle 1983) which required them to reproduce set procedures which they had just learned about. On the rare occasions when students did encounter open, more challenging problems they often lacked confidence in knowing what to do. The students needed to venture into the unknown and many of them were simply unwilling or unable to do this. There was also no real need to, students knew that the high risk occasion would pass and that the normal, unchallenging mathematical environment would resume. The students and teachers seemed trapped within a vicious circle: the teachers thought that students would not or could not think, as a result the students did not learn to think, and so the teachers views were confirmed. In this way, the 'learned helplessness' (Diener & Dweck, 1978, p451) of the students was continually re-enforced.

Davis (1992) distinguishes between two schools of thought, characterised by teachers who believe that students should be told how to do problems and teachers who believe that students should find their own ways to solve problems. The Amber Hill teachers *said* that they believed that students should find their own ways of solving problems, but, in the harsh reality of the classroom they were seduced into seeking and hearing correct answers. This seemed to be due to two important factors. First, they were concerned to get through as much work as possible and therefore did not have time to spend letting students grapple with problems:

> Edward: You're very stringent to a time limit, you haven't got the time, like, you couldn't spend, there's certain things you have to sit down and tell them. I could spend a week letting them work through on their own, or, I know this group, I could explain it to them in one lesson and they'd understand it, which one do you do?

The teachers also took this approach because they believed that students would experience failure if they did not structure work for them.

4.2.2 The pace of lessons

In years 9 to 11 the students were taught from the front of the class at a fixed pace, as is normal for setted classes (Dahllöf, 1971). In the majority of cases the pace of lessons was quite fast and all of the teachers demonstrated a concern to keep the students working through exercises quickly. Even when the teachers were explaining methods from the front of the class, they would often refer to the speed at which they were working, saying that they wanted to 'just quickly' demonstrate something. This was particularly prevalent in top set classes. The following notes are taken from a year 10, set 1, lesson, taught by Tim Langdon:

> Tim arrives and immediately rubs some work off the board and says 'OK, quadratic functions, we began, last lesson, very quickly, with $x^2 - 3x - 4$', while he writes this on the board the class watch and listen in silence, 'and we said yesterday, how did we write this? Sara, you were the star yesterday'. Sara looks at him blankly, Tim

says 'anyone?', they all look at him blankly. He moves on quickly saying 'no-one knows?, well it was (x + 1) (x - 4)', he writes this and continues 'From the book yesterday, we were practising C1 yeah?, and C3?' Sara says 'Sir we got stuck on e'. Tim picks this up saying 'Stuck on e?, well what number goes with x?' (the expression in question e is x(x - 5)), eventually someone says 'nothing' Tim says 'yes so the curve is (x + 0)(x - 5), so nothing is nought, OK, C5, C6, so...C5a, what numbers will we get? Karina? (silence), Tafaz? what did you get?' Tafaz says 'I didn't get nothing cause I didn't do it' Tim continues 'well, what is the number?' Tafaz says 'I dunno I can't do this chapter', Tim moves on 'Sara, what is the number?' Sara says '4 and 3' Tim comes back with 'so what do they give you?' Sara says '12' and Tim starts to draw a curve on the board, all of the students are watching and listening in silence. So far all of this lesson has been delivered at breakneck speed and I am not sure whether many of the students are understanding the concepts Tim is discussing. They can answer his small questions each time, such as - what do 4 and 3 make? - but I don't know how much more than this they are understanding. (Year 10, set 1, Tim Langdon)

Part of Tim's desire to move quickly through work, meant that when he questioned students from the board, he did not waste time on students who could not provide correct answers. This was a general tendency of all of the teachers when questioning students from the front. On numerous occasions I witnessed the different teachers speeding through demonstrations on the board and asking students questions, moving quickly around the class until they heard the right answers. The higher the set that the students were in, the more likely the students would be to get this fast and intense mathematical experience. The teachers did not only ignore incorrect answers, they would move on from students if they took too long to provide an answer. These tendencies all created an impression that speed was very important in mathematics. Schoenfeld (1988) reports that this does not only put pressure upon students, it shapes their perceptions of what mathematical thinking involves. He found that students believed that if they needed to spend more than about five minutes on a mathematics question they must have been doing it wrong. The implication being that questions should be answered quickly, not thought about deeply (Schoenfeld, 1988).

The speed at which teachers moved through examples in lessons derived from a desire to complete as many SMP textbooks as possible, to cover all of the content they needed to cover and to satisfy the demands of the national curriculum. This is not to say that the teachers adopted a markedly different practice prior to the national curriculum, they probably did not. But the national curriculum provided an extra time pressure and, in some senses, re-enforced their view that teaching mathematics was all about covering a certain amount of content. This motivation to complete a large number of books seemed to mean everything to the teachers. In lessons and during conversations after lessons, the teachers spent a lot of time and energy worrying about the speed at which the class were completing books. The following fieldnotes were taken during a year 9 set 1 lesson with Edward Losely:

> As the students are working through the exercise Hilary Neville comes in to get something from the stock cupboard. She stops by a group of girls and asks 'where are you up to?' then says 'Tell Mr Losely to slow down, my lot are ahead at the moment and I don't want you to catch up!' (Year 9, set 1, Edward Losely)

Hilary said this as a joke, but it served to re-enforce the notion that mathematics was all about finishing as many exercises as possible in as short a time as possible.

In the questionnaire given to students in year 9, there were no questions about the pace of lessons, but in an open question, asking students to describe their mathematics lessons, 16% of students volunteered the opinion that lessons were 'too fast'. Twenty-eight per cent of these comments came from students in set 1, when they should, proportionately, only have contributed towards 19% of the comments. Typical comments from students were:

> We are pushed hard to get work done and we work constantly at a fast pace.
> The teacher rushes through methods faster than most pupils can cope.

The speed at which teachers took students through their work had an impact upon the way students viewed mathematics as well as their learning of mathematics, both of these responses will be considered in chapters 6 and 7.

4.2.3 Links between content areas

The lessons at Amber Hill were textbook based and teachers taught the different topics as they encountered them in the textbooks. The teachers believed their job to be teaching students different procedures, not linking the different topic areas they taught or giving students an overall picture of the way different methods fitted into the mathematical domain. This generally meant that lessons involved a sequential presentation of disconnected topic areas. Different sections of the textbook would be presented to students, one after the other, without any mention of any possible connections between them:

JB: Does he talk to you about the way things are connected, do you talk about maths generally?
L: Not really, you just do bits, you just do one topic, then another. (Lindsey, AH, year 10, set 4)

A: One day or one week we're doing one thing and the next week we go onto a different topic. (Anna, AH, year 11, set 2)

The following notes were taken during a year 10 set 4 lesson with Edward Losely on angles:

The students all watch the board as EL writes 'b = 30 because they are alternate angles'. Carlos shouts out 'what does that mean sir?' EL says 'it means alternate'. He then announces 'Right we're going to move onto something else'. Daisy sighs and says 'I need a break sir', EL ignores this and says 'Textbooks out please, page 91 and writes Metric Units on the board.

Here Edward demonstrates his concern to move on to a new topic, this prevented him from explaining a term to Carlos. This sudden change in direction was not unusual. Amber Hill mathematics lessons derived their form from the artificial structure of a textbook which, inevitably, resulted in a somewhat disconnected presentation of mathematics. Hiebert and Carpenter (1992) suggest that connection making in mathematics is central to the development of mathematical understanding and question whether students should be told about connections or given the opportunity to discover them themselves. Such issues did not form a part of the mathematics department's concerns at Amber Hill and students were not encouraged to do either of these things.

Within Bernstein's classification and framing analysis (1971) Amber Hill's mathematics lessons would be ideally represented by 'collection codes' (1971, p57). Further, such a classification would be strong, rather than weak, on many counts. Importantly, the individual 'contents' of mathematics were well insulated from each other, but the lessons also conformed in terms of the explicit hierarchy which was established between teachers and students and the disconnection of lessons from everyday realities.

4.2.4 Standard mathematical methods

At Amber Hill the mathematics teachers began lessons with a presentation from the board of the mathematical methods which students were intended to use in the exercises which followed. Teachers introduced students to the different procedures in a clear and structured way. However, they did not discuss their choice of mathematical methods, nor did they discuss with students when or why they worked. Students were not encouraged to discuss alternative approaches to problems or to try their own methods, indeed many students reported in interviews that they were actively discouraged from using their own methods:

> JB: Do you get the impression in maths lessons that there is one method that you're meant to follow or do you get the impression that there are lots of methods that you could use?
> P: No, there's just one method, her method.
> D: In school you have to use the method you are told to do. (Danielle and Paula, AH, year 10, set 2)

> C: Normally there's a set way of doing it and you have to do it that way. You can't work out your own way so that you can remember it. (Carly, AH, year 11, set 1)

The teachers at Amber Hill were obviously keen to tell students about methods and strategies which were effective but they did not place these within a wider picture and they did not acknowledge the value of different or adapted approaches. The students' belief in the superiority of the teachers' methods meant that they endeavoured to learn these, even when their own methods held more meaning for them.

> JB: Does the method that's given to you make sense to you?
> J: Not as much as my own.
> JB: Your own method makes more sense?
> J: Yes.
> JB: Why do you think that is?
> J: I dunno, you... I dunno. (Jackie, AH, year 10, set 1)

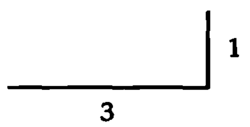
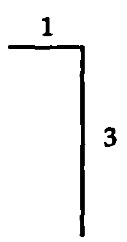
The teachers' concern to impart standard procedures meant that when students asked for help with questions teachers would re-iterate the procedure they should be using, rather than discuss the meaning of the question. The Amber Hill teachers regarded their major role in the classroom as teaching the students mathematical methods, rules and procedures. They did not regard the teaching of procedures as different from the development of sense making or understanding and they did not perceive any need to teach anything other than their own standard or canonical methods.

4.2.5 Rules to remember

In many instances I noticed that teachers actively discouraged students from thinking about mathematical relationships by telling them rules that they should remember. This, again, placed Amber Hill's mathematics lessons within Bernstein's collection code as, typically:

> 'There is a tendency ... for the young to be socialised into assigned prnciples and routne operations and derivations. The evaluative system places an emphasis upon attaining states of knowledge rather than ways of knowing'. (Bernstein 1971 p 57).

This describes the Amber Hill teachers' priority well, because the teachers strove to give the students knowledge and they did not worry about 'ways of knowing'. The following extract is taken from my notes of a year 11 set 3 class with Tim Langdon:

> Half way through the lesson TL raises his voice above the low level of noise and tells everybody to listen, he then draws a figure on the board:
>
> 
>
>
> 'If this is a line 3 long and 1 up what happens after a 90° rotation?' he asks. Some students shout out some answers 'it goes round', 'left', 'right' are shouted out by three boys, another boy makes a joke of this 'it's up, down, left, right, north, south, east, west.' TL tries again, hears another boy shout out 'it goes up' and responds, 'yes, it does this doesn't it?', he then draws:
>
> 
>
>
> The students all look at the new drawing but do not respond. 'See what's happened?' TL asks, '.. they've swapped around, the 3 goes up and the 1 goes across, so remember, when you do a 90° rotation you just have to remember to swap them

round.' All of the class listen to this instruction and then go back to their work. (Year 9, set 1, Tim Langdon)

In this extract Tim told the students to stop thinking about what happened during a rotation and remember a rule. The object of the SMP exercise was to get students thinking about the movements during rotations and to try them out for themselves. Tim discouraged the students from thinking about the movements, and gave them something to learn instead. The teachers gave the students these rules because they believed they would help them. This second extract is also taken from one of Tim's lessons:

> TL asks Michelle the answer to x(x - 5), she says '5'. TL says is there a number with this x? (pointing to the first x), Michelle says 'no', TL says, 'so there is no number with x, so it must be 0, yes?, remember that, when x does not have a number with it, it is 0'. (Year 11, set 1, Tim Langdon)

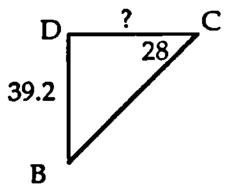
In this example the students had been given the expression x(x-5) = 0. They needed to find values of x that would made this expression true, which meant that x could be 0 or x could be 5. But Tim did not ask the students to consider the whole expression, he just said that x must be 0 because when x is on its own it has a value of 0. This 'rule' is only true in this particular instance, normally when x is on its own it has a value of 1x. It *could* be helpful for students to learn this rule if they understood its limitations and its applications, but if they understood these, they probably would not need the rule.

In another set of lessons I was surprised and intrigued by the way that Hilary Neville transformed the teaching of trigonometry into a set of rules. Hilary started the topic by drawing the following diagram:

SOH/CAH/TOA

She then told the students to write down and learn the following rules: 1) If you need the first letter in the three e.g. sin, you move to the right e.g. sin = opp divided by hyp. 2) If you need the last letter in the three you move backwards e.g. hyp = opp divided by sin. 3) If you need the middle letter you times the other two. The students started their first lesson on trigonometry by working through an exercise which required them to find a missing angle using tangents. They did this by 'moving to the right' along their arrow and dividing opposite by adjacent. The following extract is taken from a lesson during the students' third week of trigonometry. Students have been asked to find a missing side:

HN is standing at the board, she asks Carly to give her answer to the next question in the book. Carly says '28 sin times 39.2 = 10.6' HN says 'incorrect' and asks 'what is DC to the angle?' someone else says 'adjacent, HN says 'we've just found BD which is..?' someone says 'opposite' HN says 'opposite and adjacent gives?' Lindsey says 'tan'. A lot of students seem to be confused by this and are saying 'miss we don't understand'. This prompts HN to draw the triangle on the board:



She continues 'we've just found DB and that was 39.2 yeah?' Lindsey says 'no we found BD', HN ignores this and continues, 'So it's

$$\frac{39.2}{\tan 28}$$

The class do not seem to understand why 39.2 is divided by tan 28, so HN writes SOH / CAH / TOA on the board and then says, if you want to find adjacent it's backwards so it's opposite divided by tan. Later in the lesson I go over to a group who have got all of their questions wrong. I find that this is because they have divided all of their numbers, with the numerators and denominators the wrong way around When I ask them what they have done, they all say 'we know it's tan and you go backwards so it's adjacent divided by opposite and then inverse tan'. When the students say this to me I find that I cannot make sense of what they are saying without going back to the triangle and considering the different ratios in relation to the triangle. I find it difficult to work with the 'going backwards' rule. When I look at the students' work I discover that they have been moving in the same direction as they were moving for the previous exercise ('backwards') when they should have been 'moving forwards'. (Year 11, set 3, Hilary Neville).

The confusion the students experienced in using Hilary's rule demonstrates one of the possible limitations of giving the students rules that they do not understand. The Amber Hill teachers often favoured this technique of reducing mathematical principles to procedural rules that students were encouraged to remember. The teachers would also give the students cues that would help them know which rule or procedure to use at which point. These cues, as with the rules, had nothing to do with mathematical sense making or understanding. The following extract is taken from the same lesson on trigonometry at a later point when Hilary is trying to help the students who keep telling her that they don't understand:

> A lot of the class are chatting now, many of them are getting their questions wrong and seem to be very confused so HN says 'Look, Lindsey, if you have a problem with a right angled triangle what is the first thing you have to find? This is a strange question and I am not sure of the answer to it, nor are the students, Sue tries: 'the angle?' HN says 'so what do you do?' Sue offers 'sin?' HN obviously feels this isn't leading in the right direction and so starts again with 'What is the first thing you've got to do with a right angled triangle?', someone suggests 'know the two sides?' which seems to satisfy HN, she says 'yes, you've got to name them, you've got to know what the sides are.' (Year 11, set 3, Hilary Neville)

In this part of the lesson Hilary tries to deal with the students' confusion by reducing the mathematical situation to a procedure the students should learn. The first part of this procedure was - when you see a right angled triangle you label all of the sides. Students were intended to learn this so that they would label the sides of any right angled triangles they saw, rather than interpret the particular situation they were placed in and decide what information they needed. By the end of this lesson the students were showing their complete confusion. This was unusual and probably caused by the fact that trigonometry is more difficult to reduce to a set of rules than other mathematical concepts. This prompted Hilary to become annoyed and shout at them, almost as if she thought they were deliberately not understanding her:

> HN is saying 'The method is basically the same but this time we need to find the angle, look at the worked example, we need to find the given angle, marked in red. We're given two sides 4.8 and 10.6, you can see that's adjacent and hypotenuse, what is a and h?' someone says '4.8?', 'No' HN says sounding annoyed, 'is it sin, cos or tan?' One of the girls on the back row says 'what?' 'a and h?, what does that mean?' this seems to really annoy HN who suddenly shouts 'OK, shut it you lot, if you don't want to work we'll just carry on all night, if you haven't got something sensible to say shut up!'. The class are now completely silent and she continues 'you have adjacent and hypotenuse, is it sin, cos or tan?' some-one says 'cos' quietly. (Year 11, set 3, Hilary Neville)

I had to leave this lesson five minutes before the end, I caught up with Hilary later on in the day and we talked about the students' confusion. I said that the students seemed to be following the system from the exercise they had been doing yesterday, Hilary replied saying 'yes but you'd think after three weeks of doing trig they'd get it wouldn't you?' she also said 'I exploded after you left, I really had a go at them' I asked why and she said 'because they were just saying stupid things, they weren't prepared to think properly so I really shouted at them.' This reaction must have been due to her frustration at them not understanding: she simply could not comprehend that they did not understand something that was so clear to her and thought that this must be because of some lack of effort on their part.

This mismatch between Hilary's and the students' perceptions seemed to be due to the fact that Hilary understood trigonometry and, from that base of understanding, she could think about rules that appeared to be helpful to her. The students had only encountered the rules and, without a broader understanding of where they fitted into the wider scheme of things, they did not find them useful. At the end of the lesson I mentioned to Hilary that I had not seen this 'backwards' and 'forwards' system she used before. She explained that she had given them this system because the students 'liked to learn rules' and they would have found it difficult to understand trigonometry. Yet the students' misunderstanding of what Hilary was trying to lead them through derived from the fact that the students could not understand the rules they had been given or the way that the rules related to the different situations they encountered. This demonstrates the confusion that was generated when a whole area of mathematics was reduced to a set of rules. More typically the teachers would present students with shorter and easier rules, such as the rotation and the x(x-5) examples demonstrated. However these short rules did not mean any more to the students than the trigonometry rules, mainly because the students had not developed a broader picture of what they were doing and what the rules meant in relation to their work.

I would suggest that this sort of mismatch between what the teachers and what the students gain from different rules underlies much of the confusion that students experience in secondary mathematics classrooms. Mathematics teachers understand what they are discussing and they often give students structured procedures to learn that they think will simplify and exemplify mathematical concepts. But the students do not regard these procedures as particular ways of thinking about the problems or as examples of the methods in action. They view them as abstract rules to be learned and adhered to. Rules may be easy to learn, but difficult to use if they have not been placed within a wider sphere of understanding. Holt (1967) asserts that most teachers are driven by a desire to compartmentalise and provide models and structures that make sense for teachers but often do not for students. Mason (1989) talks about a similar problem in relation to the exemplification of specific and unconnected instances. 'To the teacher they are examples of some good idea, technique, principle or theorem. To students they simply are. They are not examples until they reach examplehood' (Mason, 1989 p2).

4.2.6 The teachers' motivations

The Amber Hill teachers were strongly motivated, with good intentions, to reduce the complexity of mathematical thought. This influenced their whole approach to mathematics teaching, causing them to close problems down, emphasise set methods and procedures, keep different topic areas distinct from each other and give students rules to remember. These approaches fitted in with the teachers' general philosophies about mathematics teaching, but there was evidence that the teachers had made their teaching *more* procedural and *more* rule-bound because of the social class composition of the school. Amber Hill was a largely working class school and the teachers had low expectations for their students, in particular they felt that the students had a reluctance to think for themselves or use their initiative:

> Tim: Students are generally good, unless a question is slightly different to what they are used to, or if they are asked to do something after a time lapse, if a question is written in words or if they are expected to answer in words. If you look at the question and tell them that it's basically asking them to multiply 86 by 32 or something they can do it but otherwise they just look at the question and go blank.

The different mathematics teachers shared the belief that the students were incapable of real thought but they did not relate this observation to the approach they offered at the school, but to the students themselves. In particular, features related to their background:

> Tim: I think there's a paucity of language here that the kids are using, that I think causes the problem, having taught out in Hertfordshire with much more breadth, with, if you like a professional background, there was higher performance there.

> Leisel: I think the reading is a big problem with our children, they don't want to think about what they've read, then they'll say I can't do it, I don't understand it and I think that's where it all breaks down as well. They have learned maths but they can't be bothered to think about it. It's got to do with ability and m tivation as well, because in this school we have a lot of pupils who have very little motivation, you know? They're not encouraged at home.

> Hilary: I think textbooks are better for the pupils we've got, I think they get more advantage out of it. I think there's more motivation than - they don't need as high a motivation for a textbook than they do for individualised learning And I think for the type of pupil we've got and parent, it's better that way.
> JB: What type of pupil and parent have you got?

H: Ah, um, they're not highly motivated pupils.
JB: But they work hard in lessons don't they?
H: They work hard in lessons, yes. But that's if you can build up a good relationship with them. If they want to work for you, if you can get that message over to them, yes they are highly motivated, or can be. The parents feel, many of our parents have not got qualifications and they don't feel capable of helping - they need educating on how they can help their own son and daughter. I think many of our parents feel inadequate, um, some don't care, but that's natural, um, in a cross-section. But I get the impression from most of our parents that they would do a lot more to help or support their child if they only knew how. (...) When I first came to the school I was pitching it too high for them. That was until you were used to it. I don't mean lowering your standards, I just mean that it was too high for their ability level. I still think you can get a hell of a lot more from these kids than we do, by making them feel worthwhile and confident. Having an organised atmosphere so they'll respond.

Edward: Coursework - it can be a fantastic piece of coursework, like 'how high does a ball bounce?', but not for this ability, for this level of maths. You know, to actually do that kind of experiment you need a high level of mathematics, and you are also putting a lot of physics into it and, er, I don't see how - they don't really understand the formulas. So you could give them this formula and say it's... but they won't understand, um, even to the extent, you know the brainiest, they wouldn't be sure how to measure the radius of a ball. (...) In a sense, although I would like to progress with the kids, I know how to play the game. I know that if the kids can answer every question they'll be able to do it and although they might not be able to apply it, one day in the future they might take the initiative.

The teachers' belief in the inadequacies of the students at the school made them think that a low level structured approach would be most appropriate for them and this approach did not conflict with the teachers' views about good mathematics teaching. Tim's belief in the 'paucity' of language skills in the school, diminished his expectations of students, causing him to break everything down for them. Leisel also did not expect much from her students because 'they had very little motivation'. She reported that they *had* learned their mathematics but 'they couldn't think for themselves', a distinction which showed both that the students were, in fact, motivated and that thinking for themselves was not a part of learning mathematics. Hilary felt that the background of the students meant that they needed a structured textbook approach. She described the students as lacking motivation, even though she then conceded that they did work hard. Hilary felt that they worked hard because she gave them plenty of structure and because she gave them an 'organised atmosphere', part of which meant a diet of mathematical rules. This, she felt, would make the students feel 'worthwhile and confident'. Edward believed that the students were not capable of coping with open ended work so he tried to train them to answer questions and 'play the game'.

Anyon (1981) cites a number of studies (Leacock, 1969; Keddie, 1971; Sharp and Green, 1975; Rosenbaum, 1976) that have found that schools in poor and working class areas 'discouraged personal assertiveness and intellectual inquisitiveness in students and assigned work that most often involved substantial amounts of rote activity' (Anyon, 1981, p203). One of Anyon's studies found that mathematics teaching in working class schools was procedural, rule-bound and involved the learning of set methods by rote. In more middle class, professional and elite schools the mathematics teaching involved choice, analytical reasoning, discussion of different methods and an emphasis upon mathematical processes (Anyon, 1980). Amber Hill school conformed to this pattern and the teachers' approaches in the mathematics classroom seemed to partly derive from their views about the limitations provided by the students' home backgrounds.

4.3 Discussion and Conclusion

A presentation of the distinctive characteristics of the mathematics teaching at Amber Hill presents a fairly bleak picture. However, there are many indications in the literature that there was nothing unusual about Amber Hill's approach. Textbook teaching is employed by the vast majority of mathematics teachers (Romberg and Carpenter, 1986) and this generally entails the teaching of different content areas 'that have been chopped into small pieces which focus on the mastery of algorithmic procedures as isolated skills' (Schoenfeld, 1988, p163). Doyle (1988) reports that tasks which are based primarily upon memory, formulas and procedures are common in mathematics classroom and Holt (1967) claims that the majority of teachers provide meaningless and compartmentalised models and structures for students. The Amber Hill teachers were well intentioned, committed and hard working. They kept the students on task, they prepared lessons well and they cared about their students. But they, like many other mathematics teachers, pursued the belief that students would learn and understand mathematics if they broke questions down and demonstrated procedures in a step-by-step fashion.

The structured and rule-bound nature of the school's mathematics approach seemed to have been exaggerated at Amber Hill because of the working class nature of the school. The Amber Hill teachers would probably have taught mathematics in a closed, procedural way in any school, but they emphasised this approach at Amber Hill because they believed that the students were incapable of thought or understanding. The students, in turn, were not confident or assertive with the teachers, and so they did not challenge this presentation of mathematics or question the teachers about the meaning of what they were doing. In later chapters I will show that, for many of the students, their greatest wish was to be given the opportunity to think and use their initiative as part of their mathematics learning. I will also show the various ways in which the closed and structured nature of the students' mathematical experiences impacted upon their use of mathematics in different situations.

Chapter 5 Phoenix Park School

5.1 An Overview of the School

5.1.1 Introduction

Phoenix Park is a 13-18 comprehensive school, located on the edge of Avadon, a prosperous town with a large middle-class element. There are approximately 600 students on the school's roll. The majority of students live on one of three local housing estates, one of which is infamous for its links with 'joy riding' and drug-related crimes. The school is situated in an industrial area and a large proportion of the parents used to work in the local factories before widespread redundancies made many of them unemployed. The juxtaposition of the school next to the affluent, middle-class city of Avadon makes it somewhat distinctive in the locale. It is also distinct because of a long tradition of progressive education, placing particular emphasis upon self-reliance and independence. Most of the parents who choose to send their children to Phoenix Park do so because they live in the immediate vicinity of the school, rather than because of school philosophy or practice. In a school survey of fifty parents conducted in 1987, forty-four parents said that their children lived within a twenty minute walk of the school. A few parents choose Phoenix Park because their children have special educational needs, which are given high priority in the school and a few choose the school because of its relaxed atmosphere. This contrasts with the more pressured and academic environments of the other schools in and around Avadon. Phoenix Park is usually placed near to the bottom of Avadon's LEA league table.

Phoenix Park is situated on the outskirts of Avadon and it is surrounded by a number of large busy roads. The main approach to the school involves a journey down a dual carriage-way, which mainly takes traffic to and from the local factory. Once inside the school gates the visitor is greeted by a marked change in environment. After a long, tree-lined path the school opens out to reveal a number of low buildings, spread out over a large area surrounded by grass and trees. The school has an attractive campus feel. The atmosphere is unusually calm, described in a newspaper article on the school as 'peaceful'. Students walk slowly around the school and there is a noticeable absence of students running, screaming or shouting. This is not because of school rules, it seems to be a product of the school's overall ambience. I mentioned this to one of the mathematics teachers one day and she agreed saying that she didn't think she had ever heard anybody shout - staff or student, she added that this was particularly evident at break times in the hall - 'the students are all so orderly, but no-one ever tells them to be.' (Rosie Thomas).

Phoenix Park school maintained a number of distinctive qualities, most of which derived from its commitment to progressivism. Many of the decisions that affected the life of the school were made by the school council which was run by students, the head teacher, a deputy and the school caretaker. The school council took decisions about such issues as the timing of the school day, discipline and the allocation of funds. The school used to run a modular curriculum before the introduction of the national curriculum. This meant that students did not have to choose subjects at 14 that would determine the choices they made later in their lives. Instead the school offered a range of short courses of work with different credits which the students could combine and build up into full courses.

> In the first year here you have a go at everything. After that you can get a choice and you can change your mind as you go along - so you don't have to plan your life at thirteen and make too many decisions. (Year 11 student, quoted in a school publication)

In lessons many of the subject departments used a project-based, problem solving approach with little, if any, recourse to textbooks. Students were taught all subjects in mixed ability groups. Phoenix Park students did not wear school uniform. Most students wore jeans, with trainers or boots, and shirts or t-shirts worn loosely outside. Most wore fashionable but inexpensive clothes.

A central part of the school's approach involved the development of independence amongst students. The students were encouraged to act responsibly, not because of school rules, but because they could see a reason to act in this way. Discipline was low key in the school and it was rare to see a rule imposed or referred to. In my three years of work in the school I never heard of a student being given a detention or disciplined in any other way. This non-disciplinarianism related to the head's philosophy of schooling:

> When a school (...) is allowed to create ways of helping young people experience success and grow in confidence, a concern for behaviour and discipline becomes irrelevant.
> (Paul Mardon, head-teacher)

When students acted unreasonably the staff would discuss this and negotiate with the students, rather than impose discipline. The following extract is taken from a school publication about life at Phoenix Park:

> Tony did not like maths. In addition, his name appeared on walls about the school with infuriating frequency. When his feelings about maths were expressed in large letters for all to see, it was time to take action. Conversations with Tony's art teacher, the maths co-ordinator, and the school caretaker, resulted in a plan. Tony would produce a design in his art lessons. He would then scale it up to the size of the wall of the maths building and order the appropriate quantities of paint. Then, during the school's activities week at the end of the summer term, Tony and his friend Benji would paint the mural.

The mural referred to in the extract above covered one side of the mathematics building. There were no bells in the school, which struck me as unusual when I first visited. When I mentioned this to Jim, one of the mathematics teachers, he said that this was part of the school's overall philosophy which was aimed at making the students independent in all respects, including independent timekeepers. The receptionist's job was done by students in year 9. Two students each day were taken off timetable to work as the receptionist for the school and they were given the associated responsibilities that went with this job. Students were casual in their approach to the teachers and many of the teachers treated the students as if they were adults, particularly in the way that they talked to students and chatted to them about school and non-school issues. The head would not answer students who called him 'sir' rather than his name. In lessons some teachers allowed the students to work on their own, unsupervised, in separate rooms as the students were expected to be responsible for their own learning.

> You've got a lot of freedom - it's not really like a school. The teachers don't treat you like kids. (Year 11 student, quoted in a school publication)

The pedagogy of Phoenix Park would be ideally described in Bernstein's terms as 'invisible' because the teachers had implicit rather than explicit control over students, the teachers arranged the *context* in which students explored work, students had wide powers over the selection and structure of their work and movements around the school, there was reduced emphasis upon the transmission of knowledge; and the criteria for evaluating students were multiple and diffuse (Bernstein, 1975, p116).

The school had a thriving special educational needs department which it maintained throughout the late eighties and early-nineties when many schools drastically reduced the numbers working within special educational needs. The school also had a commitment to equality of opportunity which extended beyond written policy documents. Phoenix Park was one of the first schools in the country to set up its own work place nursery for staff.

Fletcher, Caron and Williams (1985) describe the trouble experienced by schools that attempt to be progressive, in their dealings with parents. Part of the freedom Phoenix Park enjoyed in this regard seemed to be due to the working class composition of the school and the presence of parents who were less inclined to challenge the authority of teachers. In the year after my three year research study the school had an in-flux of middle class parents who quickly put pressure upon the teachers at the school to return to more traditional methods of schooling, including setting and textbook use.

> The people that come back to you at parents evening and say - "can you explain to me how maths in a mixed ability classroom works please" are middle class parents. You never hear that from anyone else, you just don't. Whether they're not confident enough to ask or they trust you completely I don't know, but they just don't ask. (Rosie Thomas, mathematics teacher)

The work of Anyon (1980, 1981) and Bernstein (1975) suggests that the progressivism of Phoenix Park was particularly unusual because of the working class intake of the school. Anyon reports that working class schools often give students work that is procedural and they discourage independent thought, analytical reasoning and decision making. At Phoenix Park the requirement to think, be independent and make decisions was explicitly encouraged from all students and the teachers did not seem to be in any way concerned about the social class of the students, nor did they concern themselves with any perceived inadequacies. This provided a marked contrast to the views of the mathematics teachers at Amber Hill. When the students first arrived at Phoenix Park the mathematics teachers were aware that they were not used to thinking for themselves and making decisions and that they found this difficult, but they believed this to be due to the mathematics approach that the students had experienced in years 1-8, rather than any characteristics of the students. The teachers at Phoenix Park were prepared to try and change the way the students thought, even though students only arrived at Phoenix Park at the beginning of year 9.

5.1.2 The staff

The staff at Phoenix Park were relatively young. In a survey conducted in 1987, 29% of the staff were in their twenties, 26% in their thirties and 32% in their forties. Interactions between staff were almost always casual and jovial. In my visits to the staffroom at Phoenix Park I was always struck by its relaxed and cheerful atmosphere. Teachers did not seem to spend their break times complaining about work load, running around organising detentions or worrying about administration. Nor did they sit in separate subject departments talking about students working or not working. Instead, break and lunch times seemed to be social occasions in which staff from different departments interacted and joked with each other. Any divisions that were apparent amongst staff appeared to reflect different philosophical or ideological positions rather than subject boundaries (Siskin, 1994). In an early visit to the school the mathematics co-ordinator said that the seating arrangements in the staffroom divided the staff into three groups: the student teachers, the progressive teachers and the "unreconstituted men". A year or so later one of the mathematics teachers gave me a similar description of the staffroom divided into the "radical left-wing" section of the staff, the student teachers and the teachers who had been at the school since it was a grammar school. This division was obvious and I quickly noticed that the majority of the staff (the 'progressive' ones) sat at one end of the room, the 'unreconstituted men' (mostly science teachers) sat at the other, and the student teachers sat in between.

The teachers at Phoenix Park were casually dressed, one day one of the more senior members of staff was wearing a t-shirt with the name of a band on it, which prompted one of the other teachers to say 'one of the very nice things about this school is you can express yourself through your clothing!'. The head teacher at Phoenix Park did not seem distinct from other members of staff, apart from the fact that he always wore a tie. Paul Mardon spent his lunchtimes wandering around the school grounds chatting to students, he knew all of the students by name and they seemed comfortable in his presence.

When I began my research at Phoenix Park the mathematics department was run by Sheila Rideout, who had a clear vision about the way mathematics should be taught. Sheila was active in one of the main mathematics associations and was well known for her innovative work in mathematics education. Sheila devised the mathematics approach at Phoenix Park, in conjunction with a working group of other teachers adopting similar approaches in their schools. Sheila left Phoenix Park in the first year of my research and her job as mathematics co-ordinator was taken over by Martin, who was her deputy at that time. A newly qualified teacher, Rosie Thomas, was appointed to the department to restore numbers. Since that time the department has been made up of three and a half mathematics teachers. Martin, Rosie and Jim all worked full-time in the mathematics department, Barbara had a 0.5 contract at the school. In my analysis of the teachers and classes at Phoenix Park I have concentrated only upon the three full-time teachers, Martin, Rosie and Jim. These three teachers taught all five of the groups in my case study cohort between them.

Martin Collins, the mathematics co-ordinator, was in his late thirties. He had a mathematics degree and was well informed about developments in mathematics education. Martin was generally very laid back about everything, including teaching mathematics and running the department. He was not an active leader and was, in many ways, the complete opposite of Sheila. He was in favour of an open approach to teaching, but he had doubts about the effectiveness of the approach they used at the school. When I talked to Jim one day he said that things had changed since Sheila had left as she was very organised, whereas Martin was very relaxed. He also said that he felt things were more coherent with Sheila and the team worked more efficiently. Martin did not seem to spend much time organising the department or bringing in new ideas. He had two young children who spent the day in the school's crèche and he often disappeared at lunchtimes and immediately after school to look after them. Martin was never particularly enthusiastic about anything and he was far from passionate about the school's unusual mathematics approach. Martin seemed to be fairly popular with other members of staff and supportive of Rosie, as a new teacher. In the classroom he was also very relaxed with students and, like all of the teachers I saw, non-disciplinarian. Martin never showed any interest in the outcomes of my research, even in the latter periods of my research when he was thinking about changing the school's approach.

Jim Cresswell was unusual, particularly for a teacher of mathematics. He was in his ear y thirties, he had an Oxbridge degree in engineering, and he was studying Chinese at degree level in his spare time. Jim used to be a youth worker and he was a practising Quaker. H always dressed extremely casually, in faded jeans, usually a sweatshirt and in winter, a woolly hat. He had very short hair and an unshaven look. In the staffroom he was often reading books about Existentialism or Marxism. In the classroom Jim treated the students as though they were adults, he rarely ever reprimanded them and when students misbehaved he had conversations with them about the inconsiderateness of their behaviour. I was often surprised in Jim's lessons by the number of students doing no or very little work for substantial portions of lessons. Jim tended to devote his time to those who asked for help which often meant that other students were left to roam around, play games or sit and chat. Jim did not seem to notice, or worry about this unless the students became disruptive in some way. At these times Jim spoke to students and, in extreme situations, ordered them out of the room. Jim often told me that he was 'no good at discipline' and he seemed concerned about this. Jim was an extremely sensitive questioner and he was skilled at guiding students through the mathematics of their work. Unlike Martin, Jim always seemed very interested in my research; this seemed partly to be driven by his concern to discover what I may be finding out or writing down about him. This partly related to the fact that Jim was a very reflective person who was concerned about his effectiveness as a teacher.

Rosie was a newly qualified teacher at the start of my research. She was in her early twenties and was enthusiastic about the school's approach and about teaching in general. In lessons she was also relaxed but made some overt attempts to keep the students on task. She often chatted to students about issues unrelated to their mathematics and she was generally liked by students. Rosie quickly became involved in the life of the school and she seemed to be a highly committed teacher. She also had a degree in mathematics.

5.1.3 Mathematics teaching at Phoenix Park

Many of the progressive principles which underscored the whole-school philosophy of Phoenix Park were represented in the mathematics approach, which made it extremely unusual. From the beginning of year 9 to Christmas of year 11 the students worked on open-ended projects, in every lesson. During this time the students were taught in mixed-ability groups. Each project lasted for approximately three weeks. The teachers introduced students to a project or theme which the students explored, using their own ideas and mathematical knowledge. The projects were usually extremely open, amounting to little more than a challenging statement.

> T: The projects that we were set, we were actually given a title in the first .. like what we had to do...but then after that you could decide how far you wanted to do it. (Tina, PP, year 11, RT)

One of the projects was called *volume 216*. In this project the students were told that the volume of a shape was 216 and then asked to go away and think about what the shape could be. They were then expected to extend their work and pursue questions and interests related to this theme. Sometimes teachers taught the students some mathematical content they thought they may need before the start of the activity. More commonly they taught techniques to individuals or small groups when they encountered a need for them within the particular project they were working on.

> S: We're usually set a task first and we're taught the skills needed to do the task, and then we get on with the task and we ask the teacher for help.
> P: Or you're just set the task and then you go about it in .. you explore the different things, and they help you in doing that.. so you sort of .. so different skills are sort of tailored to different tasks.
> JB: And do you all do the same thing?
> P: You're all given the same task, but how you go about it, how you do it and what level you do it at, changes, doesn't it? (Simon and Philip, PP, year 11, JC)

The students were given an unusual degree of choice in mathematics lessons. When projects were introduced to them they were usually given a few alternatives to choose between and when they were working on their projects they were able to choose the nature and direction of their work. Sometimes the different projects varied in difficulty and the teachers guided students towards projects that they thought were suited to their capabilities.

> T: You get a choice.
> JB: A choice between...?
> T: A couple of things, you choose what you want to do and you carry on with that and then you start another, different one.
> JB: So you're not all doing the same thing at the same time?
> Both: No.
> JB: And can you do what you want in the activity, or is it all set out for you?
> L: You can do what you want really.
> T: Sometimes it's set out, but you can take it further. (Tanya and Laura, PP, year 10, MC)

All of the work at Phoenix Park was open and students were encouraged to interpret the problems they were given and extend and investigate them in any way that they wished. Students did not learn mathematical techniques in isolation; they were only taught about mathematical procedures when they encountered the need to use them in realistic situations:

> Its approach is to try and encourage students to be able to use their mathematical knowledge, as much as to acquire new bits of mathematical knowledge so, the two go hand in hand and we try and, I suppose we focus, have focused in the past, to a great degree on the process of using mathematics rather than on acquiring the bits of archaic knowledge that people are required to do to get through the hoops of GCSE. So, it's very much of an approach where we want the students to acquire skills, that they are going to be able to use and apply in the rest of their lives, rather than to get some kind of body of knowledge. (Martin Collins, mathematics co-ordinator)

Martin's description characterises the notion of an integration code approach (Bernstein, 1975) in which the orientation of the pedagogy is 'less concerned to emphasise the need to acquire states of knowledge, but more concerned to emphasise how knowledge is created.' (Bernstein, 1971, p60)

The scheme of work used by the mathematics department looked incredibly sparse. Each academic year was split up into four or five topic areas. Within each area the scheme of work gave a number of written objectives, a range of projects or investigations and a list of national curriculum attainment targets. For example, in year nine the students were introduced to five topics: squares and cubes, connections and change, counting, geometry and position and place. At departmental meetings the teachers discussed the activities that they were about to use and any modifications they were intending to make. There was little written documentation of the work. Some of the activities were written out on pieces of paper that were photocopied for the students, others were written up onto the board at the beginning of lessons.

The mathematics department had a relaxed approach to both the national curriculum and the assessment of work. Their scheme of work was cross-referenced to the national curriculum attainment targets but had no finer level of detail than this. When the teachers assessed the students' projects they wrote comments, describing what they considered to be good or bad about the work and ways in which students could improve the work. The teachers did not give grades and they did not keep records which they could pass on to teachers when the students changed groups. Most groups were taught by the same teacher as they moved up the school, unless a teacher left. The only other formative assessment the teachers made of the students took place when they walked around the room and interacted with students. Bernstein describes the change in assessment focus required by an invisible pedagogy, because the evaluation procedures need to be multiple and diffuse and they are not easy to conceptualise in terms of a precise measurement (Bernstein, 1975). This, he suggests, means that assessment tends to focus upon the whole child rather than some particular competencies. This broad focus was true of Phoenix Park's assessment in which the teachers tried to give a general picture of a students' achievement on particular projects. This stood in contrast to the Amber Hill approach which conformed with their 'visible' pedagogy. The Amber Hill teachers gave the students marks or percentages and, as Bernstein describes, their profiles consisted of the 'grading of specific competencies in a clear and unproblematic way' (Bernstein, 1975, p143).

The students learned mathematics through the use of open-ended projects until January of year 11. At this time they started examination preparation The projects were abandoned and the students were introduced to formal methods and notations. The students were grouped according to the examination they were entered for, with foundation level students in the same groups and intermediate and higher level students in the same groups. The teachers used the blackboard more frequently to explain procedures and the students practised procedures within textbook questions, worksheets and past examination questions. The students reported that they found this system of learning mathematics very different to the one that they had, by then become accustomed to.

The project-based Phoenix Park approach shared a number of characteristics with the research projects that have recently been developed to offer a type of 'cognitive apprenticeship' in school. This was partly due to the fact that the Phoenix Park projects were relatively 'authentic' (Young, 1993 p45) and partly because the students were only introduced to mathematical facts and procedures when they encountered the need to use them within their projects. Brown, Collins & Duguid (1989) offer two examples of mathematics instruction in the vein of cognitive apprenticeship, one of these is Schoenfeld's problem solving (Schoenfeld, 1985), the other Lampert's teaching of multiplication (Lampert, 1986). These projects are given as examples of cognitive apprenticeship because students are introduced to different concepts through 'continuing authentic activity' (Brown, Collins & Duguid, 1989, p39). Young (1993) purports that there are four critical tasks involved in the practical implementation of cognitive apprenticeship. These are: the selection of authentic tasks which will afford the acquisition of appropriate concepts; provision of the necessary 'scaffolding' to support learners in their work; support for teachers that will allow them to track pupil progress and interact knowledgeably with pupils and a defined assessment role that conceptualises what it means to assess situated learning (Young, 1993 p 46). Phoenix Park were characteristically unsystematic about all, except perhaps the first of these criteria, but offered what can probably be described as a relaxed version of cognitive apprenticeship. The teachers did not regulate instruction, gradually withdrawing support (Hennessy, 1993) and they had not developed particular models of assessment, but, essentially, students were only introduced to concepts and procedures through authentic activities (Brown, Collins & Duguid, 1989). Young presents the essential feature of cognitive apprenticeship to be authenticity - 'situations must at least have some of the important attributes of real-life problem solving, including ill-structured complex goals, an opportunity for the detection of relevant versus irrelevant information, active/generative engagement in finding and defining problems as well as in solving them, involvement of the students' beliefs and values, and an opportunity to engage in collaborative interpersonal activities' (Young, 1993 p45). All of these features were well represented within Phoenix Park's project based approach.

The main difference between the Phoenix Park approach and cognitive apprenticeship related to the help that students were given. At Phoenix Park the teachers gave out projects and left students to develop them and use their own ideas. The teachers were available to help students but the students could not rely on this help as there was only one teacher in each room. Students were encouraged to work together and help each other as part of their work and most students did this. However, the students were certainly not given an intensive 'scaffolding' (Wood, Bruner & Ross, 1976) experience by the teachers and they were left to think and use their own initiative more than a student would be in a traditional apprenticeship situation.

5.2 Important Characteristics of the School's Approach

In this section I will describe the important features of the school's approach. These are the features that appeared to have the greatest impact upon the students' learning of mathematics.

5.2.1 Open learning

Probably the most distinctive, influential and unusual aspect of the mathematical approach at Phoenix Park was its complete openness and the freedom that this created for students.

> G: In books, it tells you everything, you read everything off the question, you read the question and you have to answer it. Here you just have to make up your own, he just tells you what you have to do and then you have to do it yourself. (Gary, PP, year 10, JC)

> A: It was a big change from my last school, having the books and then just having it written on the board and being told to get on with it. (Andy, PP, year 11, RT)

The mathematical approach at Phoenix Park was open from the time when projects were described to students to the time, two or three weeks later, when they gave them in. This openness manifested itself in a number of ways. The way in which the projects were described and defined, the way in which teachers answered the students' questions and the way in which teachers guided students. The students at Phoenix were not given specified paths through their activities, they were merely introduced to starting questions or themes and expected to develop these into extended pieces of work. When they asked the teachers questions the teachers seemed to make deliberate efforts not to structure the work for students:

> JB: When the teachers help you here, do they talk to you generally about the topic or do they break it down and tell you bit by bit what to do?

A: Very general, they hardly give you an answer.

JB: Is that a bad thing?

D: No usually it helps, 'cause then they don't really give you the answer, you still have to work it out for yourself. (Alex and Danny, PP, year 11, JC)

In the following extract the students have just started the *volume 216* project. The teacher has introduced this by asking the students to find some shapes that have a volume of 216, think about them, investigate them and form their own problems related to them. Some boys have, fairly typically, asked exactly what they are meant to do:

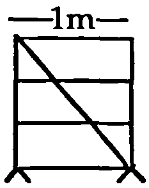
After about 10 minutes 3 boys call MC over and say that they don't know what to do. MC goes over, but he does not suggest ways in which they could start the project, he does not give them an easy step into the work, instead he talks about shapes, saying that some shapes can be very tall but have the same volume as short shapes. MC does not structure the problem for them at all, but gives them a holistic overview of the mathematical situation. He leaves the students and they start to sketch out shapes. (Martin Collins, year 10)

Thus the openness of the approach did not only relate to the way that mathematics was introduced, it related to the way in which teachers interacted with students and supported them in their work:

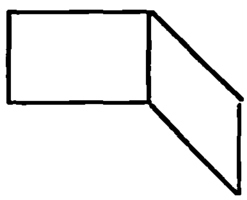
A: Well, I think first of all you have to try and find your own methods, then if you really get stuck the teacher will come and give you suggestions for stuff and tell you how to like, progress further and then you can kind of think about it. (Andy, PP, year 11, RT)

I have chosen the following extract as a typical example of the way in which projects were introduced at Phoenix Park. In the extract Jim is introducing a new activity called '36 pieces of fencing' to a year 9 group of students.

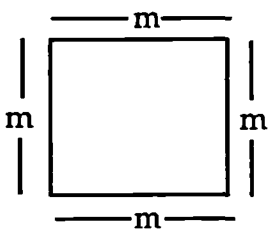
Twenty-fi e students come in and sit down. Sixteen boys and 9 girls gather around the board. A boy asks 'Sir are we gonna start a new project?' JC says 'Yes, the title of the piece is *36 pieces of fencing*, (he writes the title on the board) so, you need a piece of paper - it only needs to be a scrap piece of paper at the moment, but make sure you've got something to write on' a few get up and collect paper from a stand in the room. JC continues Can we have a bit of hush please? Right, you have a piece of fencing and from the side it looks like this:



it has little legs on, like this and it is 1 metre wide. They have little hooks on and you can hook the gates together. You can put them at any angle, so those from the side would look like this:



He continues, 'What we are interested in is what sort of shapes can you make with 36 pieces of fencing?' A girl asks 'sir does that count as one piece?' JC says yes, the students then start calling out shapes, a boy offers a square, a girl a hexagon, Amy asks 'do you have to use them all?' JC says 'Yes, there are rules' and writes a heading: Rules on the board and then, under this, *use them all on every shape* saying 'it makes them more manageable if you have to use them all'. Then, 'any other shapes?' A girl says 'rectangle' JC asks 'just one?' a boy says 'a square is a rectangle' and JC says 'yes, we've already got a special type of rectangle'. The students continue shouting out shapes, a boy says 'rhombus' a girl says 'parallelogram' and JC is adding all of these to a list on the board, another boy says 'pentagon' and JC stops at this and says can you?'. The boy says 'yeah', JC asks 'how many sides?' and a few offer '5'. A girl says 'you've got 36 fences' and JC says 'well you can have a pentagon, but what will it be like?', there is silence, so he asks 'will the sides be the same?' the students all shout 'no' JC asks 'so what will it be called?' a boy offers 'irregular'. JC writes *irregular pentagon* then asks for more shapes, one boy offers 'quadrilateral' and JC says 'yes, well, these are all quadrilaterals' and he points to some shape names. He puts brackets round these on the board and writes *quadrilaterals* next to them. He then continues with 'we've got a triangle but is there only one?' a girl says 'there's loads' JC says 'yes there's loads so lets put an s on' and makes it triangles, then 'so, we've got 4 sided, 5 sided...' a boy offers 'octagon' and a girl says 'yes, 8 sides' JC asks 'yes, but what will happen? someone says 'there'll be some left over' and JC says 'yes, or irregular, not all the same length, so *pentagon* and writes *(irregular) heptagon (irregular) octagon (irregular)*' a boy offers 'nonagon' and JC tells him to say it louder so that everyone can hear JC writes it on the board with (9) next to it, then asks 'will it be regular or irregular?' a girl says regular and JC asks why, she says 'cause 9's go into 36'. JC asks 'what other regular ones can we have?' there is silence and he adds 'well the definition seems to be if the number of sides go into the number of fences' a boy says 12 and JC writes *dodecahedron (12 sided),* someone offers 18 and JC says he doesn't know what that is called but writes up *18-sided shape,* a boy says '3 sides' and someone else says 'that's a triangle'. JC asks 'OK how many regular triangles can you make?' someone says 'one' and JC says 'yes, where I've written regular you can also have irregular ones' he then asks 'which are easier to draw?', someone says 'irregular' and JC says 'OK shall I make it harder and say we only want regular ones?' some say no to this and some say yes, JC says 'we can put another rule in if you want' and writes under the rules heading *only make regular shapes* but then adds *(you can break it sometimes).* Justin says 'I always break the rules sir' and JC says 'really Justin'. Then 'now, tell me something about a square' a girl says 'they're all the same length' JC says 'yes so I have to go round 4 lengths all the same and if I call this m' he draws:



and says 'I'll say 4 times m equals what?' a girl and boy say 36 and JC asks 'so how do I work out what m is?' a few say 9, one girl says '36 divided by 4', JC responds to these saying there are 2 ways of looking at it, we can say 4 x m = 36 by thinking about our times table, or we can say 36 divided by 4 = m, but you can only really use the first when it's a whole number'. Then 'so how big is it?, what is the area?' a few say 81 and JC says 'so the area is 81 metres squared, why metres squared?, because it's an area, when you work out area it's metres squared'. Then 'I want you to look at all of those shapes and find ones that are possible to do, and I'm interested in the area of them, why might I be interested in area? what is it useful for? I may be making a garden, or a pen'. JC suddenly turns to a boy near him who has been chatting incessantly and says 'Michael, it is irritating you talking all the time, OK?' Michael looks repentant and JC continues 'so I'm interested in area, I'd like you to explore these shapes and find areas, now, the first thing I'd like you to do is record what I've been talking about, my writing isn't sufficient, you need to put things in your own words, your version of the problem, expand it, write what it means, pick out shapes, decide what order you need to do them in!'. As the class go back to their seats and start work, Matt, who is new to the school, says 'sir, I don't understand these shapes, I don't think I've seen them before' JC says 'well that could be one of your tasks, find out about the shapes, look them up in your maths dictionary, or you could look in an ordinary dictionary'.

Most of the class start work, some are talking, some have started straight in with drawing squares, some check with JC what they are meant to be doing, two boys sitting at the back are talking about something else and not working. Matt is looking up the shapes in a dictionary, most students seem to have started doing the task, without explaining in their own words what they have to do, as JC suggested. Three boys sitting together at the back are slow to get started, they write a few words, talk for a while, write some more and so on. Two boys pick up their table and move it round to avoid the sun, JC is kneeling down by the side of somebody saying 'you draw it whatever size you want to draw it'. Most of the students' introductions say 'we need to see how many shapes we can make out of 36 fences' or something similar. Four girls are sitting having an animated and excited conversation about what all of the different shapes are: 'is it a quadrilateral?'(laughs) another 'what's that?' another '- a trapezium?'. They seem very interested. As I pass Julie she checks with me what a regular shape is before she writes out her definition in her introduction. One boy has written a short introduction and found the area of a rectangle and triangle but is copying all of this onto a new piece of paper, I ask him why and he says he has made some spelling mistakes. Some students have now written about a paragraph. Three boys at the back have only written a heading and a sentence, most of the rest of the class have moved onto examples. One boy is finding the area of a triangle and asks me how, I show him how it is half the area of a rectangle, he picks this up quickly and finds the height of his triangle, multiplies it by the base and halves it. None of these students are using calculators, nor do they ask for them, although they are available. One of the boys is finding out which is bigger a rectangular area or a triangular area, JC comes over and says 'so which was bigger?' the boy tells him and he asks 'is that what you would think, does it look bigger?' they discuss this for a while. A few students seem to be copying their partner's introductions. (Jim Cresswell, year 9)

The extract above is a fairly typical example of an introduction to a project which the students then spent approximately three weeks working on. The only slightly unusual aspect was that the students were given one project to work on, rather than a choice of projects. Jim's introduction incorporated a number of features which related to the openness of the approach. Jim introduced the problem of *36 fences* by getting the students to think about the different shapes that were possible. He did not spend much of the time at the board telling the students information, rather he created an arena for discussion and negotiation. During the course of this discussion the students encountered the need for certain parameters, such as 36 fences must always be used and irregular shapes are not allowed. Jim did not tell the students these constraints at the beginning but waited for them to become relevant to the discussion. At the end of the class discussion Jim told the students that it was not enough to write the problem out in his words, they needed to re-formulate it in their own words, using their own thoughts. Importantly, Jim did not give them any particular question to answer, he just said 'I am interested in area, I'd like you to explore these shapes and find areas.' When Matt said that he was not familiar with the shapes Jim suggested a place that he could find out about them, he refrained from telling Matt what he needed to know. When the students started their work Jim left them to their own devices. He did not 'police' the room or check that they were going about things in a specific way. When he could he interacted with students and engaged them in conversations about their work. When one of the students said that a triangular area was bigger than a rectangular area Jim did not focus upon the answer, he asked him whether he would expect this, whether it looked bigger - he encouraged him to think about the situation.

It was also typical that students did varying amounts of work in the remainder of the lesson. Some copied Jim's introduction or another student's introduction in a fairly absent-minded fashion and did nothing else. Some started their work in a relaxed way, interspersing it with non-mathematical conversations, others engaged in lively debates about the problem. These varying responses to the task were allowed to develop undisturbed and Jim did not attempt to change anything the students were doing, or not doing. By the end of the first lesson the students had produced varying amounts of work which focused upon different questions and problems. As time went by and more lessons were spent on the theme the students began to diverge more and more, both in the amount of work they did and the topics they worked on.

The teachers had different strategies for supporting students when they were beginning their activities. At the beginning of a project on *volume 216* Rosie asked the students to plan their work and 'work out what direction they could take it in' for homework. The next lesson she announced that, rather than taking the homework in she would go round and discuss everybody's plan with them as 'this would be a more constructive thing to do'. Teachers introduced activities to students which they knew were mathematically rich, but the teachers did not have fixed ideas about the way in which students would interact with the problems. In a year 11 lesson Shelley was working on an investigation called *discs*. She started off working with 4 discs (or numbers) and then moved onto five:

> After working on the problem for a while Shelley takes it over to MC to show him. He looks at the work, laughs and says 'golly, I didn't know it could get that complicated' Shelley says 'shall I stop?' MC says 'no, carry on', Shelley says 'I want to carry on

because I want to see what happens to the horizontals when I continue up in this direction'. (Martin Collins, year 11)

This extract is interesting, not because Shelley was extending the activity in an unusual or idiosyncratic way, but because Martin had obviously not encountered the work before. Shelley also demonstrated in this extract that it was the unknown aspect of the exploration that held her interest. She was genuinely interested to know what the mathematical outcome would be of extending the work. When students showed the teachers their work they did not seem to expect the teachers to have seen it before. They did not expect them to look and say 'yes that is right' but to look and see whether they were moving in an interesting direction. Such interactions then formed the basis for dialogue between the students and teachers.

The students at Phoenix Park gave many indications that they eventually formed their expectations and ideas about learning mathematics in relation to an open approach. This was demonstrated clearly by a lesson in which a student teacher attempted to teach the students in a more traditional and closed way:

TG starts the lesson by asking the class to copy what he is writing off the board. He is writing about different forms of data, qualitative and quantitative. The students are very quiet and they start to copy off the board. TG then stops writing for a while and tells the students about the different types of data. He then asks them to continue copying off the board. After a few minutes of silent copying Gary shouts out 'Sir when are we going to do some work?', Leigh follows this up with 'Yeah are we going to do any work today sir?' Barry then adds 'This is boring, it's just copying'. TG ignores this and carries on writing and talking about data. The boys go back to copying. TG asks Lorraine if she 'is OK' she says 'No not really, what does all this stuff mean?' TG ignores this and goes back to writing on the board. Gary persists with his questioning, this time asking 'Sir, why are we doing all this?' TG says 'We are just rounding off the work you have done.'

After about 20 minutes of board work TG asks the students to go through all of their examples of data collection that they have done over recent weeks and write down whether they are qualitative or quantitative. Peter asks 'Sir what's the point of this?, aren't we going to do any work today?' TG responds with 'you need to know what these words mean' Peter replies 'But we know what they mean, you've just written it on the board so we know'. (Tony Garrett, student teacher, year 10)

This series of interactions is particularly interesting because the group of students continually resisted the work Tony was doing with them because they simply did not regard it as work. A group of boys repeatedly asked 'whether they were going to do any work today', indicating that they did not regard copying as work, probably because it did not require any thinking or present them with a problem to solve. When Tony told them to classify data as quantitative or qualitative so that they would learn what the words meant, Peter questioned the point of this because they had already been told what they meant. Yet the mathematics offered in this example is fairly typical of a standard secondary school mathematics lesson in which the teacher explains what something means to students on the board, they copy it down and then they practice some examples of their own. The degree of resistance the students provided to this work seems to indicate that they found the approach alien. In another lesson of Jim Cresswell's one of the students complained to Jim about being away last lesson saying 'It was terrible we had this teacher who acted like he knew all the answers and we just had to find them'.

The students gave other indications that they regarded their mathematics learning as an open experience. In interviews I asked the students to say whether they thought mathematics lessons were similar to any other lessons at the school. Sixteen of the twenty students said that mathematics was most similar to art, English or humanities; nobody compared mathematics to the subjects more traditionally linked to it such as science.

> JB: Is maths similar to any other lessons at Phoenix Park, or is it different?
> L: I suppose it's a bit like English and art and stuff, English, when you're left to do your own work - they explain at the beginning what to do and then you're left on your own to do it' (Lindsey, PP, year 11, JC)

5.2.2 Time on task

A second striking aspect of school mathematics at Phoenix Park related to the number of students choosing not to work in lessons. In my early visits to the school I was surprised by the number of students who were 'off task' in lessons and this continued to be a source of concern to me. In their year 10 questionnaire students were asked to describe their mathematics lessons to someone from another school. The most popular description from 23% of students was 'noisy'. In a typical lesson at Phoenix Park approximately one-third of students would be wandering around the room, chatting about non-work issues and generally not attending to the project they had been given. In some lessons, and for some parts of lessons, the numbers 'off task' would be greater than this. Some students remained off task for long periods of time, sometimes all of the lessons; other students drifted on and off task at will. In a small quantitative assessment of time on task I stood at the back of lessons and counted the number of students who appeared to be working ten minutes into the lesson, half way through the lesson and ten minutes before the end of the lesson. Over eleven lessons with approximately 28 students in each, 69%, 64% and 58% of students were on task respectively.

The freedom that the students experienced to stop working when they wanted to seemed to be created by a number of inter-related facets of the Phoenix Park approach. It was partly to do with the nature of the mathematical approach and the fact that students could be wandering around the room and chatting with other students as part of their work. It also related to the fact that the students could all have been working on something different which made it difficult for teachers to monitor the amount of work that they did:

> T: It gives some people more of a chance to muck about.
> JB: Why?
> T: Because, for instance, at the end of a lesson if the teacher wanted to check how much work you'd done he couldn't, but if you started at number 1 he would know that you hadn't got to number 20 or whatever, but you could just say, well I did it in this lesson and you could have done it in the last lesson. (Trevor, PP, year 11, RT)

More important than both of these factors, the freedom the students experienced seemed to relate directly to the relaxed and non-disciplinarian nature of the three teachers and the school as a whole. This seemed partly to be a philosophical position, the teachers allowed students to take their work to other, unsupervised rooms if they wanted to. A gesture that, of itself, indicates that students were meant to be responsible for their own learning. But the teachers also encouraged students who were not working to work, which suggests that they did not believe that students should choose whether to work or not. It seemed that the teachers were relaxed about the number of students on task because they generally had a relaxed approach to lessons. Most of the time the three teachers did not seem to notice when students stopped working, unless they became very disruptive. All three of the teachers seemed concerned to help and support students and, consequently, spent almost all of their time helping students who wanted help, leaving the others to their own devices. The three teachers were not markedly different in this regard, although Jim Cresswell's lessons were noticeably more chaotic than those of the other two teachers.

> I think the weakness of my teaching style would be very much that I depend on willingness and co-operation and, you know, if somebody is motivated to do the stuff they will achieve well. (Jim Cresswell)

Jim Cresswell often told me that he was 'no good at discipline' and my lesson observations showed that students in his classes were less 'on task' than the classes of other teachers. This seemed partly to be because he treated the students in a very adult way which some of the students took advantage of. For example there was a small classroom attached to Jim's room that nobody used. Jim used this room as a 'talking room' and students were meant to work in there if they wanted to talk and work, leaving the other students to work in quieter conditions. Jim was not concerned about his inability to see the students in this room and he rarely asked students to work when they were not doing so, unless they became disruptive. When Jim did tell students to work the result was often ineffective. Typically the students would say something back to Jim which sparked a debate between Jim and the student. At the end of this the student usually went back to not working and Jim was called away to help somebody. The following extract is taken from one of Jim's lessons, it has been chosen because it is a fairly typical example of one of Jim's lessons. The students were in year 11 and had been grouped into examination groups. This was a 'foundation' group of students, many of whom lacked motivation:

> As the students arrive they immediately ask which room will be the quiet room and about half of them disappear off into the talking room. JC takes the register and then says to Mark 'I have just read something about you which means you have to get your folder out and work', Mark says 'I suppose I have to' and then explains to Lisa, sitting next to him, that he has signed a contract saying that he will come in at 8.30 and stay until three and work all the time inbetween. There are seven students in the 'quiet room' at the moment, five of them are leaning over JC's desk, the other two are sitting talking. There are currently six students in the talking room. The noise of something being used to hit the desks comes from the talking room. Three boys come in late announcing that they have 'been for a fag' and two of them go straight into the talking room. JC calls Louise to his desk and goes through some work with her.
>
> Students in the talking room are fairly quiet now but the door is shut and I don't know whether they are working or not. Luke, one of the smokers asks 'where's Tim sir?' JC says 'he's probably in the other room, being a pain', 'shall I look?' Luke offers, 'no, sit down' says JC and goes over to look himself, as he does so more hitting noises come from the room. JC goes in and returns with two boys in tow, presumably those responsible for the noises, they are laughing. The room goes momentarily quiet, 'who wants paper?' JC asks, this is aimed at those who have just accompanied him from the talking room. Mark, the one with the contract, starts a conversation with JC about Martin Luther King. Mark, who is black, starts telling JC that what Martin Luther King wanted was 'stupid' and wouldn't work, they discuss this for a few minutes, JC asks Mark if it is

worth trying to 'give peace a chance' he follows this up with 'how about giving your maths a chance?' and leaves him. Mark continues the conversation with Lisa, explaining to her what he had found out about Martin Luther King.

Gary tells JC that 'they are playing table football in the talking room', he tells JC to 'go straight through the door and look to your left', JC does this, discovers the table football and brings those involved back into the main room. Barry, in the 'quiet' room is sitting with his feet on the desk playing with a Pritt Stick. Eventually Barry falls backwards off his chair, the others in the room laugh, Barry decides to stay on the floor and continues lying in the position he fell in. Gary puts his walkman on. Mark and Lisa are still discussing Martin Luther King. Twenty minutes into the lesson JC tells two boys who are draped across their desks to get some work out, JC then wanders around to Lisa and picks a CD off her desk. He then discusses the CD with Lisa and Mark.

I walk into the talking room and find that more of the students are working in here than in the quiet room. There are nine students in the room, one girl is sitting on her own eating a Kit-Kat, working. A girl and boy sit and discuss their careers booklets, a group of four boys are generally messing about and not working. Gareth runs into the room and sticks sellotape on David's hair then runs out again, David goes to the door of the quiet room and shouts 'funny fucker' through the doorway. JC comes in and takes David into the quiet room. The boys on the table David has left get their work out but continue chatting.

Back in the quiet room about one third of the students are working, JC is having a conversation with four or five of the students about arranging cubes. A group of three boys are sitting discussing some trouble they are in with the police; they discuss this for about fifteen minutes before JC comes over and tells them to work, at first they are quiet but two minutes later they are talking again. Another boy, Barry, who has now got up off the floor, walks around stapling people's jumpers. Suddenly the room becomes quiet, for the first time all afternoon. Barry shouts out 'somebody talk, it's all gone quiet'. (Jim Cresswell, year 11, foundation examination group)

This extract is fairly typical of a lesson at Phoenix Park in that some students worked, some did very little and most drifted on and off task at different points in the lesson. The lesson was also typical to the extent that Jim was fairly relaxed about the students who were not working, even when they were, for example, walking around stapling people's clothes. When Jim did take action against students this was in response to other students telling him about their behaviour. Jim rarely seemed to notice when students were n t working, usually because he was helping somebody. In a number of Jim's lessons I observed, so few of the students appeared to be working that I started to have serious doubts about my research. At the end of my research I found out that some of the newer, more middle-class parents at the school had complained about Jim's teaching which resulted in the head visiting his lessons and telling Jim that only about 30% of students were on task.

Both Rosie Thomas and Martin Collins showed more overt concern to keep students on task than Jim. But whilst both teachers were more likely to react to the extremes of behaviour that Jim tolerated, both teachers seemed unconcerned about students who sat and chatted through most of their mathematics lessons. When the two teachers did ask students to work this often had little effect, the students worked for a few minutes then went back to chatting. The degree to which students were on task in lessons also varied between classes, year groups and aspects of lessons.

5.2.3 Independence and choice

There were many overt and covert ways in which the students at Phoenix Park were encouraged to be independent. This meant that they needed to take on some responsibilities as part of their mathematics approach in order to succeed. For example, the students were not given exercise books for their work, they used pieces of paper. At the start of activities they were given blank or lined pieces of A4 paper as well as graph paper if they needed it. The students each had a box file which they kept their work in. Nobody took charge of this process for the students, papers were not collected in at the end of lessons, students were meant to either take them home and bring them back again or store them in their box-file. Students often came to lessons having forgotten or lost their work from the previous lesson and so took a new piece of paper and continued on that. Some of the students were very disorganised and their box files were made up of odd collections of extracts from different activities. At the end of each project students were meant to gather together all of their work, present it in a coherent fashion and summarise it. The students were rarely encouraged to be careful or tidy and many of the finished projects looked very messy in comparison with a more typical mathematics exercise book.

At around Easter of year 11 the school sent pieces of coursework to the examination board. At this time the students were told to choose their best two pieces and give them in. The choice of coursework was left up to the students, although the teachers would give guidance if asked. Often the pieces of coursework which were sent to the board were unfinished, either because the students showed little concern for the task of choosing their coursework or because the students had no complete projects to send:

L: They left it to the last minute as well, like they kept saying you've got to have work for your GCSE and that, but if you didn't hand your projects in, in years 9 and 10 they weren't really bothered were they?
H: No.
L: And at the end now they say we need them. (Louise and Hannah, PP, year 11, JC)

Here the students related the incompleteness of their work to the lack of enforced discipline or control from their teachers. Another important aspect of the mathematics approach which required the students to take responsibility for their work involved the choice that students were given about the projects they could work on and the direction the students took their work in. The students at Phoenix Park were given considerable and varying amounts of freedom in their choice of work, their approach to work, the way in which they behaved in lessons, the organisation of their work and even their work environment.

P: The amount you do is always up to you isn't it? How much homework you do and especially coursework for GCSE, it's your work, it's your responsibility, I mean however much work you get in, that's always going to be reflected in your mark. (Philip, PP, year 11, JC)

This choice and the students' independence had an important impact upon their approach to mathematics, which will be considered in later chapters.

5.3 Discussion and Conclusion

The mathematics approach of Phoenix Park was unusual, particularly because of its openness, the degree of choice the students were given, the independence students were encouraged to develop and the freedom the students had over their work environment and their work rate. These features of the mathematics approach should be located within the overall context of Phoenix Park school, which was an unusually progressive institution that aimed to develop students' independence and decision making abilities. The Phoenix Park approach was mathematically different from the majority of schools because learning mathematics was not based around the learning of different mathematical procedures. Rather, the students were engaged in activities and projects in which the need for certain mathematical techniques became apparent. This approach necessitated a relaxation of the control teachers had over the structure and order of the classroom. The Phoenix Park teachers were not concerned about this, in line with their general approach to mathematics teaching and learning. Their concern was to give students mathematically rich experiences and to help them use mathematics, rather than to maintain order and a high work rate. They were concerned with the quality, rather than the quantity of the students' mathematical experiences and with understanding rather than coverage. This meant that the Phoenix Park classrooms looked very different from those of Amber Hill and the experiences of the students were also markedly different. In the next chapter I will consider the impact of these different approaches upon the students' views of mathematics and their general and mathematical behaviour.

Chapter 6 The Students' Responses

6.1 Introduction

In this chapter I shall review the students' main responses to their different mathematical approaches. I have organised the responses into three main sections for Amber Hill and four sections for Phoenix Park. The three sections shared by both schools are: enjoyment, engagement and students' views about the nature of mathematics; a fourth section, prompted by the Phoenix Park data is: independence and creativity. These sections served as a framework within which the main responses of the students could be organised. I have not devoted the same amount of space to the different sections for the two schools. This is because some issues were more important to the students in one of the schools. I shall first describe the main responses of the students at Amber Hill, then discuss the responses of the Phoenix Park students. At the end of the chapter I will present some results for both of the schools.

6.2 Amber Hill

6.2.1 Enjoyment

In my interviews, conversations and observations of lessons over three years, many of the Amber Hill students reported to me that they were bored by mathematics and that mathematics lessons were 'low in their list' of favourite subjects. In questionnaires the students were fairly guarded in their descriptions of mathematics, which is probably to be expected, particularly as the questionnaires were administered by teachers and the students may have been wary about committing views to paper. However, questionnaires offered a more general, if perhaps less valid, perspective on the students' opinions. Students in year 10 were given a questionnaire that asked them to describe their mathematics lessons to some-one from another school. The students' responses were then coded as very positive, positive, neutral, negative or very negative. This gave the following distribution of results:

Table 6.1 Amber Hill year 10 questionnaire descriptions of mathematics lessons

	very positive	positive	neutral	negative	very negative	n
n	0	36	58	51	9	154
%	0	23	38	33	6	

The positive comments students gave fell into three main categories. Six students just stated that lessons were enjoyable or quite enjoyable, 7 said that lessons were interesting and 6 said that they liked their teacher. The reasons that the students gave for disliking mathematics were also given in interviews and classroom conversations. In all of my interviews with the Amber Hill students, even with those students who were chosen because they reported that they liked mathematics in their questionnaires, I always received negative reports of mathematics. This was not due to any prompting on my part. I generally started interviews with 'Can you describe a typical maths lesson to me?', this was usually enough encouragement for the students to describe all of their negative feelings about mathematics. These reported experiences were made more valid by the extremely high degree of consistency between the reports of different students.

The main sources of disaffection the students reported in their questionnaires and in interviews conducted in years 10 and 11 were: the lack of variety in the approach, the lack of freedom or openness they experienced and working as a class at a set pace. Each of these features will be discussed in turn below:

a) Variety in lessons

The students gave various indications that they were bored by their mathematical experiences. In their year 9 questionnaire students were asked 'what do you dislike about the way you do maths at school?' 49 students (31%) criticised the lack of variety in the school's approach and 77 students (48%) reported that they would like more practical or activity-based work. Typical comments were:

> Maths would be more interesting if there were more projects to do.
> I don't think we should work on boring textbooks all the time.
> The way we always look at the same old textbooks (boring) and never change systems.

The students were dissatisfied, not only because they worked through textbooks for the vast majority of the time, but because they thought the questions within the books were very similar:

S: The books are a bit boring, the chapters aren't really that good and they repeat the same questions over and over again, like when they explain something they do the question and then you have to do about twenty of them at the same time.
G: Yeah and you only needed to do one, to know what's going on. (Steven & George, AH, year 10, set 3)

The students did not blame their boredom upon the intrinsic nature of mathematics. They were aware that they could gain enjoyment from learning mathematics, because they liked their coursework lessons and most of them had enjoyed their primary school mathematics. The students merely felt that it was inappropriate and unnecessary to work through SMP textbooks all of the time and they wanted more variety in their mathematics teaching:

JB: If you could change maths lessons what would you do?
R: I'd have maybe one lesson a week on the booklets, one on activities, one where you get a problem and you have to solve it - just a variety. (Richard, AH, year 11, set 2)

The students were far from unreasonable in their requests. In their year 10 questionnaire the students were asked what they liked about mathematics lessons. The most popular response from 50 students (31%) was 'I like maths when we do activities', 4 students (3%) said that they liked their textbook work. When they were asked what they disliked about mathematics lessons the four most popular responses were: working from books (22%), not understanding (20%), work being all the same (19%) and work being boring (17%).

b) Open-ended work

In their textbook lessons the students did not think that they were able to develop ideas, use their initiative or think about mathematics. They became aware of the value of these features of their learning when they were given open-ended coursework projects to work on for three weeks of year 10. The students believed that the openness they experienced within coursework made mathematics more enjoyable, but also helped them to learn:

D: I feel restricted when we're doing the books.
R: Coursework is better than the bookwork you know, because with coursework you could go out and you can just - you learn more by doing something on your own, you know, if you're doing something on your own, you learn, well I found I learned more

by doing something on my own than I had done with the teacher. (Richard & David, year 11, set 2)

JB: Do you think you learn different things from the coursework?
S: Yeah it's a better way to learn.
JB: Why is that?
S: 'Cause I can figure it out for myself, the books just, it's too much leading you through it. (Sacha, AH, year 11, set 4)

The students contrasted their experience of coursework, in which they had the freedom and space to think for themselves, with the constrictions of their teacher-led, textbook approach:

H: Sometimes I'd like him to just leave us to get on with it, like just to go through a chapter for ourselves and see if we can work it out for ourselves, rather than having him go through it all.
M: Yeah that's why I liked the coursework, when we had to arrange a daytrip weren't it?, that was good that was, I enjoyed that.
H: Because we could do it all ourselves and we needed to use like our own initiative, that's what I liked.
JB: Don't you think you can do that normally?
Both: No.
H: No we're always told like, exactly what to do and the way to do it and sometimes I'd like to see whether I could work it out for myself. (Helen & Maria, AH, year 11, set 1)

The students described their coursework in terms of an increased cognitive demand. They did not regard coursework as an easy option and for many it meant a lot of effort and hard work, but they valued this experience because it allowed them to *think* and to feel ownership of their mathematics, in ways that textbooks never did:

S: She could like, what's the word? make us think, say things to make us think, but she couldn't actually say - you could do this. So we was helped, but, she didn't tell us what to do, she'd give us the idea and we had to work it out, it was good.
JB: Why did you think that was good?
S: 'Cause I can still remember how we worked everything out and I can use them like in other things.
JB: Why is that, that you can use it in other things?

L: It was a project, so it was going from one little thing and getting this big result at the end - working through on your own, going through different stages I was really proud of it actually, it was good.
S: We was dead chuffed weren't we?
L: You feel more proud of the projects when you done them yourself, if it's just working through the book, you can't feel proud - well, you can get them right and nobody cares - like you've seen it, it doesn't really matter, but if it's like a big project and you can see like what mark you've got at the end and if you've worked hard and if you get a good mark you feel really good about it. (Sara & Lola, AH, year 11, set 3)

The students felt a sense of ownership for their coursework projects, which they related to the amount of effort they had put into their work and the requirement to think about what they were doing. In the textbooks the students were 'le d through it', they were not allowed to 'work things out' and they felt 'restricted'. The students were clear that the openness of coursework enhanced their learning; they also reported that they enjoyed their mathematics when they worked in this way. Students were asked in their year 9 questionnaire (before they had encountered coursework) to describe the 'most interesting piece of mathematics' they had ever done in a lesson and almost half of all students (49%) cited the same mathematical experience - using logo on the computer. When they completed a similar questionnaire in year 10 and were asked to describe their favourite lesson 62% of students chose their 'open ended tasks' and 9% of students chose computer activities. A further 17% either left the space blank, said that they could not name a good lesson or described something that was not related to mathematics, such as the teacher being away. Of the students who actually described a mathematical experience 81% chose their 'open ended task' as their best ever mathematics lesson.

c) Working at their own pace

When the students began year 9 at Amber Hill they had just experienced two years of working through individualised booklets at their own pace. For many the change from this system to a system whereby the whole class worked through pages of a textbook at the same speed was quite a shock. In interviews conducted in years 10 and 11, working at the pace of the class was a major complaint for almost all of the students and one that they variously related to disaffection, boredom, anxiety and underachievement. Many of the students were unhappy because they felt that the pace of lessons was too fast, this often caused them to become anxious about work and to fall behind, which then caused them to become more anxious. This response was particularly prevalent amongst the top set girls. However the anxiety caused by fixed pace lessons did not only prevail amongst the top set students or girls. In the following extracts the students all relate the fixed pace of lessons to a loss of understanding:

A: I preferred the booklets.
S: Yeah 'cause you just get on with it don't you?
A: Yeah, work at your own pace. You don't have to keep up with the others.
JB: Do you feel that now?
A: In a way because if you don't do all the work, then you get left behind and you don't understand it. (Suzy & Anna, AH, year 11, set 2)

L: Well in the first two years you worked at your own pace, this last year or two you got to do it all, with everyone else at the same time, at the same speed, and if we're too slow or something, you've got to be able to do it, quickly, even if you've got it wrong[1], just to catch up with everyone else, which is bad, 'cause you don't learn it, you're just rushing and trying to make sure you get it done just so you don't get in trouble and you can catch up with everyone else. (Lindsey, AH, year 11, set 4)

The majority of students related their reservations about class teaching to what they perceived as a resultant loss of understanding. However, whilst some students, who were generally girls, complained about the fast pace of lessons, other students in the same groups said that their learning was diminished because lessons were too slow. These were usually boys:

M: It's silly now, it's just, most of the people slow the class down, gets it more boring.
C: You don't learn as much.
M: Like people laze around, when they've completed the work...say we've completed the work and we can go further up the book, we have to do that piece of work and then stop, and wait for the others to catch up and then people laze around. (Chris and Marco, AH, year 11, set 4)

The fact that some students complained about the pace of lessons being too fast, whilst other students in the same classes, complained about lessons being too slow seems to reveal an important limitation of a class taught approach. For the teacher it shows how difficult it is teaching a group at the same pace, even when they are of 'homogeneous'

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1 The teachers did not seem to be particularly aware that students got questions wrong in their exercises, (because they were rushing through their work). The teachers rarely checked classwork. They assessed the students by giving them the 'review' sections of the textbooks and asking students to repeat questions that they had answered incorrectly.

ability. Amber Hill divided the students into eight sets which should produce relatively little variation amongst students in the same set, yet the students reported that the variation between them caused problems. The complaints of the different students at Amber Hill may also reflect the fact that the ability of a student does not necessarily indicate the pace they feel comfortable working at, although this is an assumption that class teaching to setted groups is predicated upon. Despite the variation amongst girls and boys in their preferences for the pace of lessons, they were clearly united in their view that a fixed pace of lessons decreased their opportunities for learning. None of the girls or boys interviewed expressed a preference for their individualised lessons because they allowed them to do less work, the students were clear that they preferred working at their own pace because it gave them a greater access to understanding:

> JB: What did you think about the booklets you used in the first two years here?
> S: I thought they were good.
> L: I dunno if the booklets were good - or if it was working at your own pace.
> JB: Do you like going at your own pace?
> S: Yes definitely.
> L: Yes, but it's not like we go slow if we go at our own pace, it's not that we go slow, we don't think oh going at our own pace, lets do one sum a lesson type of thing.
> S: It's good, because you know if you understand something you can move on.
> L: And if you don't you can spend more time on it, you spend more time on it - but she wants to move on, so you just leave that bit and go onto the next bit even though you don't know the bit before and you don't understand the chapter. (Sara and Lola, AH, year 11, set 3)

Research studies have shown that the presence or absence of mathematical anxiety is an important determining factor in a students' response to mathematics (Buxton, 1981). Women and girls, in particular, have been known to suffer from mathematical anxiety (Tobias, 1978; Dweck, 1986; Leder, 1990), and this has been shown to have serious negative consequences for their achievement (Fennema & Sherman, 1977, 1978; Hart, 1989). At Amber Hill mathematical anxiety was commonplace, particularly amongst girls, and in interviews the students linked their anxiety to their perceived lack of understanding which, they felt, was partly caused by class teaching. The effects of setting upon the students' learning and pre-disposition towards mathematics will be discussed in more depth in chapter 10. The differential responses of girls and boys to setting arrangements will also be considered in chapter 9.

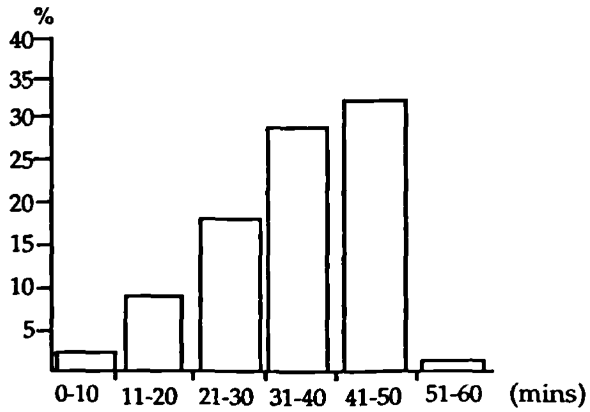
6.2.2 Engagement

In the vast majority of lessons that I observed, students showed a marked degree of uninterest, uninvolvement and boredom with their work. Passivity was commonplace, demonstrated by rows of students quietly copying down methods without any apparent desire to challenge, question or think about their work. In the following extract Edward is labelling the angles of a figure on the board:

> EL asks the students 'what about c?' Scott offers '100', EL accepts this and puts it on the diagram. 100 is wrong, the angle is 120, but none of the students say anything. Later I tell EL that the angle is 120 and he stops the students and says 'Oh yes, mistake everybody, c is 120'. At this point about 6 of the students say 'yeah I thought it was'. (Year 11, set 4, Edward Losely)

The fact that the students did not correct Edward, even though they knew the answer was wrong did not surprise me, because this was indicative of the students' passive, unresponsive behaviour in mathematics lessons. This was the way that students responded to what they perceived as the boredom of lessons. In Corrigan's study of working class boys and their responses to schooling (1979) he found that 'mucking about' was a major activity in classrooms and not paying attention was endemic. Many of the Amber Hill students did not pay attention during substantial parts of lessons but they normally confined their 'mucking about' to quiet, non-mathematical conversations with friends. When I recorded the number of students working in lessons, over 90% of students appeared to be on task at three different times, but when I asked all of the students to write down, anonymously, how many minutes they worked in lessons, the average of all of the times given by the 147 students was 38 minutes.

Figure 6.1 Students' perceptions of time spent working at Amber Hill



n = 147, mode = 45, mean = 37.7

The difference between my records of time on task and the students' perceptions of the time they spent working in lessons was partly due to the fact that students made sure that they looked as though they were working when they were not. It may also have been due to the fact that the students often worked through exercises they were given to do, without any thought or involvement:

> A: So we do equations and formula's, like roughly the same thing you do and you don't even like think about what you're doing, you just do it 'cause it has to be done. (Alan, AH, year 11, set 3)

> K: As soon as you walk out the class.. well actually as soon as the classroom starts, you don't really know anything, 'cause you've switched off. You walk in and you think, oh another boring lesson and you're off. As soon as you've walked out, you've forgotten about that lesson. (Keith, AH, year 11, set 7)

The students often worked because they thought they had to, not because they enjoyed their work or because they were engaged with the mathematics. This meant that they were often working without thinking:

> C: I think people start to think.. oh, I hate it, but we've got to do it, we haven't got much choice.. I think that's the thing that keeps people going on most of all. Like if you asked people is maths your favourite subject, hardly anyone would say it is, but they know they have to do it, cause it keeps getting drilled into them that you need maths, it's a good qualification. People think oh well I've got to do it so I might as well do it. (Carly, AH, year 11, set 1)

This attitude of 'I might as well do it' was not conducive to the students' learning and the students were aware that they could work in mathematics lessons, without gaining very much from it:

> M: Yeah it depends if I'm in the mood, but I think, if it's like a lesson when I decide to work hard and I do work hard then I find that I succeed more, and I understand it more really, rather than if I just do it because I've got to do it. (Maria, AH, year 11, set 1)

> D: Coursework was better because you could spend time on that and get involved with it, and you worked because you wanted to. (David, AH, year 11, set 2)

The difference the students highlighted between working when they wanted to work and working because they had to is an important one. This is partly because this distinction may underlie the difference between learning and working procedurally. Almost all of the students talked about the time they spent in mathematics lessons 'switched off' and working without thought. In a sense the Amber Hill students were exercising their own style of control over their work through a process of self steering and deselection (Lundgren 1977), the only control that was open to them. This difference between learning and working without thought is also important because it raises questions about the validity and usefulness of time on task assessments. The students at Amber Hill would have looked to anybody as though they were hard at work, but their assessments of the time they spent working and their comments in interviews show that they spent much of their lessons with their minds elsewhere. Peterson, Swing, Stark & Waas (1984) also found that students' reports of attention were more valid indicators of classroom learning than observers' judgements of time on task. As part of one of my assessment activities I asked some of the students to complete an open-ended GAIM task called 'Planning a Flat'. At the end of the first lesson three of the girls looked at their flat designs in complete amazement and said to me 'God that's the most work I've ever done in a maths lesson!'. I was slightly surprised by this because I knew that the girls completed a lot of questions in their lessons, but they obviously did not regard this as *work* in quite the same way. The distinction the students drew between engaged and non-engaged work is also important because it suggests that the pre-occupation teachers often have with keeping students quiet and orderly (Doyle, 1984) may not be justified. The Amber Hill students said that they were engaged when they believed an activity to be worthwhile, at other times they would 'work' but get very little out of it. This suggests that the nature of tasks that students are given to do is far more important than keeping them quiet and on task and 'high risk' tasks (Doyle, 1984) that may increase classroom disorder are ultimately worthwhile.

6.2.3 Students' views about the nature of mathematics

a) Rule following

The Amber Hill students held a view that mathematics was all about memorising a vast number of rules, formulas and equations. They did not believe that mathematics was a rich or varied subject, nor did they regard it as a 'doing discipline' or a 'practical skill that is carried out in the reign between the inspired art and the technique' (Treffers, 1987, p60).

A: At the end of each chapter if they had a list of rules it would be so much easier, like now, I'm revising, I'm trying to go through the book and I'm looking for the rules, if they had the rules at the end it would be better ... I bought a revision book from the school and they've got a few rules in it but again they sort of, you know, you've got to try and find the rules, they're not all set out for you. (Alan, AH, year 11, set 3)

The students' belief in the need to remember rules had an important influence upon their mathematical behaviour. As a result of approximately 100 lesson observations at Amber Hill I defined two main behaviours which seemed to influence the students' mathematical decision making. One of these I termed 'rule following' because when the students approached new situations they did not try and interpret what to do, they tried to remember a rule they had learned. Part of the reason students did this was that they thought it was inappropriate to try and interpret the particular situation given to them, as there was only one set way to solve each question and this involved remembering a rule:

S: In maths, there's a certain formula to get to, say from a to b, and there's no other way to get to it, or maybe there is, but you've got to remember the formula, you've got to remember it. (Simon, AH, year 11, set 7)

L: In maths you have to remember, in other subjects you can think about it. (Lorna, AH, year 11, set 1)

The students did not only believe that there were a lot of rules that could be learned in mathematics, they believed that they *had* to remember these rules in order to solve questions. Some of the students were so convinced of this, they did not see any place for thought within mathematics lessons. The predominance of the students' belief in the importance of remembering rules was further demonstrated by the year 10 questionnaire devised in response to my fieldwork. In one item of this questionnaire students were asked which they believed to be more important when approaching a problem, remembering similar work done before or thinking hard about the work at hand. Sixty-four per cent of students said that remembering similar work done before was the more important. This view appeared to be consistent with the strategies they employed in class and was, in many ways, indicative of their whole approach to mathematics. The Cognition and Technology Group at Vanderbilt (1990) note that when novices are introduced to concepts and theories they often regard them as new 'facts or mechanical procedures to be memorised' (1990, p3). The Amber Hill students rarely seemed to progress beyond this belief.

There were many negative consequences of the students' belief in the rule-bound nature of mathematics. One of these was that their desire to remember different rules, meant that they did not try and interpret and understand what they were doing. Thus, they would learn rules and use them in situations that they fitted into, but when the situations changed they became confused. This resulted in situations such as the one reported in chapter 4: the students had learned a trigonometry 'rule' and used it when they needed to find missing angles, but when they needed to find missing sides, they just carried on using the same rule. They did not think that there was anything wrong with this until they got all of their questions wrong.

A second negative consequence was that when students encountered questions that did not require an obvious and simplistic use of a rule or formula many did not know what to do. In these situations they would give up on questions or ask the teacher for help. A third problem was provided for the students who thought that mathematics *should* be about understanding and sense-making (Lampert, 1986). These students experienced a conflict at Amber Hill because they wanted to attain meaning and understanding but felt that this was incompatible with a procedural approach:

> JB: Is maths more about understanding work or remembering it?
> J: More understanding, if you understand it you're bound to remember it.
> L: Yeah, but the way Mr Langdon teaches, it's like he just wants us to remember it, when you don't really understand things.
> JB: Do you find that it is presented to you as things you have got to remember, or is it presented to you as things you have got to work through and understand?
> L: Got to be remembered.
> J: Yeah remember it - that's why we take it down in the back of our books see, he wants us to remember it. (Louise and Jackie, AH, year 10, set 1)

The students who wanted to understand their mathematics, were mainly girls, which is an idea that will be developed further in chapter 9. These students were in many ways more disadvantaged than the students who were happy to just learn the rules and play the game. Hiebert and Carpenter (1992) assert that students who are asked to memorise methods and procedures in mathematics lessons will inevitably believe that mathematics is mainly a matter of following disconnected rules and symbols. The Amber Hill students conformed to this position for they, like many other students of mathematics (Schoenfeld 1988, Erlwanger, 1975) believed that mathematics was all about memorising rules and equations. This view caused problems for the students because it had an enormous impact upon their behaviour. The students were confined by this belief and in new situations they did not try and think about what to do, they tried to remember a rule or method they had used in a situation they thought was similar. However, because in mathematics lessons, they were not encouraged to discuss different rules and methods or think about why they may be useful in some situations and not others, the students did not know when situations were *mathematically* similar. This was part of the reason that they developed a second form of behaviour that I have termed cue-based.

b) Cue-based behaviour.

Frequently during lesson observations I witnessed students basing their mathematical thinking on what they thought was expected of them, rather than on the mathematics within a question. Brousseau (1984) has talked about the 'didactical contract' (Brousseau, 1984, p113), which causes students to base their mathematical thinking upon whatever they think the teacher wants them to do. I was often aware that the Amber Hill students used non mathematical cues as indicators of the teacher's or the textbook's intentions. These sometimes related to the words of the teacher, but students would also use such cues as the expected difficulty of the question (what they thought should be demanded of them at a certain stage), the context of the question, or the teacher's intonation when talking to them. The following extract is taken from my fieldnotes of a year 9 set 1 lesson:

> After a few minutes Nigel and Stephen start to complain because there is a question that "is a science question, not a maths question", they decide they cannot do it, and I go over to help them. According to the problem, 53% of births are male babies and 47% female babies, but there are more females in the population. Students are asked to explain this. I ask Stephen if he has any idea, and he says, "because men die quicker" I say that this is right and leave them. Soon most of the students are putting their hands up and asking for help on the same question. Carol, a high attaining girl, has already completed all of the exercise but has left this question out and says that she cannot do it.
>
> Later in the lesson, Helen has her hand up and I go over. The question says that "58.9 tonnes of iron ore has 6.7 tonnes of iron in it. What percentage of the ore is iron?". While I am reading this, Helen says "I'm just a bit thick really". I ask Helen what she thinks she should do in the question, and she immediately tells me, correctly. When I tell her that she is right she says, "But this is easier than the other questions we have been doing: in the others we have had to add things on and stuff first". A few minutes later two more girls ask me for help on the same question: both of these girls have already completed more difficult questions. (Year 9, set 1, Tim Langdon)

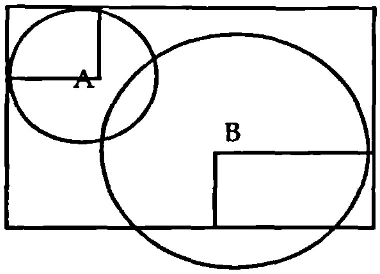
These two examples demonstrate different forms of cue-based behaviour. Nigel and Stephen and all of the other students who stopped working when they reached the question on babies, stopped because the question required some non-mathematical thought.

They could do the question, but they thought that their ideas must be wrong because they did not expect a question with "science" in it, in a mathematics lesson. The girls gave up on the question on iron ore because the mathematical demand was different from what they had expected. The previous exercise had presented a series of abstract calculations in which the students were asked to work out percentages that required them to "add things on and stuff first". In the next exercise the questions were mathematically simpler, but they were contextualised. The writers of the textbook obviously regarded these as more difficult, but the girls were thrown by this, because they expected something more mathematically demanding. This expectation caused them to give up on the question. It is this sort of behaviour that I have termed cue-based, because the students were using irrelevant aspects of the tasks, rather than mathematical sense making or understanding, to cue them into the right method or procedure to use. Schoenfeld (1985) asserts that this sort of cue-based behaviour is formed in response to conventional pedagogic practices in mathematics that demonstrate set routines that should be learned. This sort of behaviour, which was common amongst the Amber Hill students, meant that if a question seemed inappropriately easy or difficult, if it required some non-mathematical thought, or if it required an operation other than the one they had just learned about, many students would stop working. This cue-based behaviour is also demonstrated by the following extracts:

> Lina calls me over and says that she is stuck. She needs to start a new exercise in the textbook and says that she does not know what to do. I explain to her and she says 'but this is the same'. I look at the previous section and find that there is no difference between that and the section she is 'stuck' on. This similarity is enough to cause Lina to ask for help, she could do the mathematics in the questions, but she was not interpreting the question mathematically, she was trying to interpret the SMP structure. (Year 11, set 1, Tim Langdon)

The following extract is taken from one of Hilary Neville's lessons:

> Students have been given a drawing of a rectangular lawn with two smaller rectangles drawn onto it. The lawn has 2 positions marked A and B on it and they are told that there are sprinklers at these 2 positions that spray water in circles. The students are given the diameter of the sprinklers' 'circles' and told to draw diagrams of the lawn, the rectangles and the sprinkler circles into their books. They are then told to shade all of the area that gets wet. Almost all of the students have drawn the correct circles, which are something like:



However, approximately three-quarters of the class have shaded the diagram wrongly. Instead of shading all of the smaller circle and all of the bigger circle that overlaps with the 'lawn' they have shaded the circles, but left the rectangles that are contained within the circles unshaded. I ask two boys why they have left the rectangles out, saying 'can you just tell me why you think these areas won't get wet?' they both look at their diagrams and say 'Oh, they will' and decide to shade them in. I ask quite a few other students why they have left the rectangles out, one says 'I don't know, because those lines were there' another says 'why would they have given us those rectangles if we were just meant to shade over them?' The students over rode their mathematical sense making in order to obey an implicit set of SMP rules. (Year 9, set 2, Hilary Neville)

This final extract is taken from a year 10 set 3 lesson with Hilary Neville:

HN writes an equation on the board and explains how you move the letters together and move the numbers together to simplify it. She then tells everyone to do section b) in the book. When students start to read question b1 complete confusion breaks out and the room suddenly becomes filled with noise, students asking each other what to do or calling out requests to HN for help. The book has explained how 3n - 2 + 4n + 7 can be simplified to 7n + 5 and HN has demonstrated this on the board. The students were obviously expecting to use exactly the same mathematical operations in exercise b). Instead of this, the first question says 'If n = 5, work out the values of 3n - 2 + 4n + 7 and 7n + 5 and check that they are the same'. This seems to cause problems for *all* of the students as they are being asked to substitute n = 5 into the two equations which is not what they have just done on the board. HN gradually gets called to nearly all of the students in the room and at each one says 'look, you've just got to put the numbers into the equation to prove that they are the same', some accept this and try it, Jane and Karen confirm with each other that that is what they are meant to do, decide that 'it is silly' but do it anyway. After a few minutes HN is obviously fed up with giving the same explanation to everybody in the class and stops the whole class, 'listen everybody, engage your brains, all they're trying to do is get you to realise that they are equal'. All of the class listen to this in silence, Jane puts her hand up 'does that mean the answer is 40?'. 'No' shouts HN 'the answer is yes, they are equal!'. The students seem to be very confused, some of them don't understand why they are being required to do something which is slightly different from what they have just been told about, others are confused because the question tells them that the two expressions are equal and so they cannot work out what the "answer" is. By this point HN is drawing the balance machine used in the year 7 and 8 SMP booklets to try and jog their memories about balancing equations and substituting numbers. The class look blank, 'Don't you remember the booklet, it had rabbits on one side of the scales?', this seems to prompt some recognition from some students. (Year 10, set 3, Hilary Neville)

In these different extracts the students were using irrelevant aspects of tasks to cue them into the right thing to do. For example, the lines on the diagram, the difficulty of the question, the relationship between the question and the procedure they had just learned about were all used as cues which caused students to answer questions in a certain way or to give up on questions. This sort of behaviour is important because it gives an indication of what the students perceived the point of mathematics lessons to be. The students did not act in this way because of the idiosyncratic nature of the questions they were given, but because of the goals and expectations they had formed in their lessons. These involved getting through exercises in any way possible, not thinking deeply about mathematics. When students thought they knew how to work something out, but thought they must be wrong because of an irrelevant cue, they did not have the confidence to think - 'this must be mathematically correct', they trusted in and followed SMP rules, which meant more to them than their own sense-making and understanding.

Lave (1988) has demonstrated that adults often base their mathematical decision making on the situation or setting, rather than the mathematics within a task and that such decisions are socially organised. These students seem to be performing an equivalent procedure, relating their choice of method to the implicit rules within their setting, which, at that time, were governed by their SMP textbooks. The students in Hilary Neville's class indicated that they could not (or would not) substitute numbers into a formula. The students were confused because their SMP book did not ask what they had expected it to ask. Hilary responded to this by describing an SMP book they had encountered earlier in the course. The students did not remember this so Hilary tried to jog their memories by recalling the context of the work - the rabbits on the scales. She gave an explicit encouragement to link the mathematics with the irrelevant context of the SMP book, rather than with sense or understanding. This kind of encouragement was consistent with the students' reported beliefs about learning mathematics.

The students used cues, such as implicit SMP rules, to help them know what to do in different situations. In a sense, the students were forced to do this because they had not learned to interpret situations or think about them mathematically. Their cue-based strategies were also effective, they often allowed them to attain correct answers, it was only in unusual situations such as the ones described above, where the questions did not fit into the usual SMP prototype, that the students became confused. But these classroom strategies were ultimately destructive, because they worked against mathematical thinking. The methods discouraged sense making and understanding and they were completely ineffective in non-SMP and non-classroom situations.

6.3 Phoenix Park

6.3.1 Enjoyment

In interviews, conversations and lesson observations at Phoenix Park the students gave a very much more varied picture of their enjoyment than the students at Amber Hill. Whereas the Amber Hill approach prompted a fairly consistent reaction from the students, the Phoenix Park approach seemed to divide the year group into those who loved it, liked it and hated it.

In their year 9 questionnaire 43% of Amber Hill students and 52% of Phoenix Park students reported enjoying mathematics all or most of the time. In the year 10 questionnaire, when students were asked to describe their mathematics lessons to some-one from another school, the Phoenix Park students were significantly more positive than the Amber Hill students ($\chi^2 = 6.3$, d.f. = 2, $p < 0.05$)[2], with the following distribution of answers:

Table 6.2 Phoenix Park year 10 questionnaire descriptions of mathematics lessons

	very positive	positive	neutral	negative	very negative	n
n	2	26	20	19	0	67
%	3	35	27	25	0	

In the year 11 questionnaire 45% of Amber Hill students and 55% of Phoenix Park students rated mathematics as one of their favourite five subjects and 53% of Amber Hill students, compared with 60% of Phoenix Park students said that they enjoyed working on mathematics problems.

2 Using collapsed table with very positive and positive, negative and very negative combined.

Questionnaires and interviews in years 9 to 11 showed that the Phoenix Park students who liked the approach generally did so because it was varied, because they were given a choice about what they did and because they had the freedom to work in any direction. These were also the reasons that other students disliked the approach. Some students found it too open and they did not want to be left to make their own decisions about their work. What for some students meant freedom and opportunity, for others meant insecurity and hard work.

> V: I thought the activities were really interesting because you had to work out for yourself what was going on, you had to use your own ideas.
> JB: How does that compare to the SMP work you used to do in middle school?
> V: Boring, it was boring doing stuff out of books. (Vicky, PP, year 11, JC)

> S: You're able to explore more, there's not many limits and that's more interesting. (Simon, PP, year 11, JC)

Other students complained that they were often left on their own not knowing what to do and they wanted more help and structure from their teachers. These students felt that the approach placed too great a demand upon them. They did not want to have to use their own ideas or structure their own work and they said that they would have preferred to work from books:

> M: You don't mess about if you've got a book there, you know what to do. (Megan, PP, year 10, RT)

There were approximately five students in each class who disliked and resisted the open nature of their work. These students were mainly boys and often they were disruptive, not only in mathematics but across the school. The rest of the students varied in their response to mathematics and their levels of enjoyment usually depended upon the particular projects they were working on. Some lessons they enjoyed a great deal, others they were more ambivalent towards.

In the year 9 questionnaire item which asked students to describe the 'most interesting piece of mathematics' they had ever done in a lesson the Phoenix Park students responded in a very different way from the Amber Hill students. Whereas 49% of Amber Hill students chose logo, Phoenix Park students described a variety of different projects. Five different projects were nominated by at least 5% of students: 11% of students chose logo, 10% an activity called frogs, 9% a probability project, 8% chose the 'maths day' (when they worked on mathematics projects all day), 6% chose an activity called limping seagulls. Another 36% of students chose other class projects which they had encountered over the past year. The question asked students to describe the most interesting piece of mathematics they had ever done in a school lesson. Many of the Amber Hill students described a lesson from primary school or from year 7 and 8. At Phoenix Park all of the students described one of the projects they had experienced since starting at Phoenix Park in year 9 and all descriptions were positive, for example:

> Horse racing was good because the answers were unexpected.
> The best piece of maths I think I have done was boxes as I did quite a long project.
> Statistics, I thought this was the most interesting, I wrote a large amount about marriages and divorces using the book *Social Trends.*

The Phoenix Park students' replies gave the impression that they were genuinely interested in the projects that they had chosen and they did not report that mathematics lessons were monotonous or boring.

The variation in opinion between different students at Phoenix Park was revealed by the year 10 questionnaire item that asked the students to describe what they liked and disliked about mathematics lessons. The three most popular descriptions of what the students liked were 'the relaxed atmosphere' (23%), 'the maths we do' (17%) and 'nothing' (13%). The four most popular descriptions of what the students disliked were 'work that is boring' (16%), 'lessons are too noisy' (15%), the teacher (12%) and 'nothing' (9%), a further 11% of students did not give an answer.

The overall picture of enjoyment gained from Phoenix Park was therefore mixed and I have not discussed the aspects of mathematics that the Phoenix Park students disliked in the detail that I discussed the dissatisfaction of the Amber Hill students. This was because the Phoenix Park students expressed considerably less concern about their school's approach and there was not a similar consensus of opinion about its reported inadequacies. A consideration of the various forms of data, including questionnaires, interviews and lesson observations suggests that approximately one-third of the Phoenix Park students positively liked mathematics, particularly because of its variety and openness. Approximately one half of students enjoyed some of the projects some of the time and disliked others at other times and the remaining students disliked the approach, particularly the freedom and openness they experienced. I will consider this last group of students in more depth in a later part of this chapter.

6.3.2 Engagement

a) The general picture

The students at Phoenix Park varied in the extent to which they engaged with their mathematics. The students were essentially left to decide whether or not they worked in class. This meant that some students worked with enthusiasm on their mathematics projects, whilst others would find talking or disrupting the class more interesting than their work. It was unusual to see students working in a 'switched off' procedural way. This was because the nature of the work made it very difficult to work in this way for much of the time and so students tended to be either interested and working or uninterested and not working. The majority of students in all of the classes worked at some times in lessons, but they did so in a very relaxed way, with about as much time off-task as on-task. In most classes about two-thirds of the students drifted on and off task at will throughout lessons; a small group of students worked in a committed and motivated way for almost all of the lessons and a small group of students appeared to do very little work in any lessons. The following extract is taken from the third lesson on the theme '36 fences' which was described in chapter 5, taught by Martin Collins. Some of the students have considered the areas of different rectangles with a perimeter of 36, others have moved on from this and have started to investigate the areas of different shapes:

> Mickey has found that the biggest area for a rectangle with perimeter 36 is 9 x 9 and is moving on to find the area of equilateral triangles, compared with other triangles; he seems very interested by his work. He finds one area and is about to find another when he is distracted by Ahmed who tells him to forget triangles, he has found that the biggest possible shape made of 36 fences has 36 sides, he tells Mickey to find the area of a 36-sided shape too and leans across the table explaining how to do this excitedly. He explains that you divide the 36-sided shape into triangles and all of the triangles must have a 1cm base, Mickey joins in saying 'yes and their angles must be 10 degrees!' Ahmed says 'yes but you have to find the height and to do that you need the tan button on your calculator, T-A-N, I'll show you how, Mr Collins has just shown me'. Mickey and Ahmed move closer together to do this. On another table I ask Clare what she is doing, she says that she is working out the area of a hexagon and she shows me her diagram. She explains that she is working out the area by dividing it into six triangles, she has drawn one of the triangles separately. She says that she knows that the angle at the top must be 60 so she can draw it exactly to scale using compasses and find the area by measuring the height. Clare seems to have made these decisions on her own and she is clearly interested in her work. On another table six girls have not started work even though we are 20 minutes into the lesson, they are sitting colouring

on their folders; another group of boys are working out the areas of rectangles but they do not seem to be particularly interested in what they are doing. (Year 9, Martin Collins)

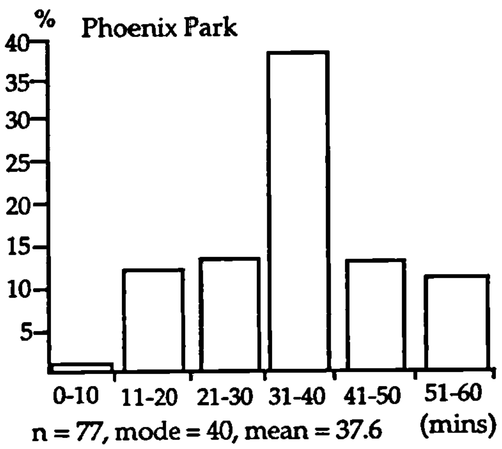
This extract demonstrates the different amounts of enthusiasm and interest that were commonly in evidence during Phoenix Park lessons. Mickey and Ahmed were two high ability boys who were extremely involved in their work and who seemed genuinely excited to be discovering some new information. The interest they showed for trigonometry, because they could *use* a tangent ratio to help them find something out within their project, seems important to contrast with the Amber Hill students' experiences of trigonometry reported in chapter 4. Clare was not a high ability student but she was also interested in what she was doing and the decisions she had made. The six girls who were drawing on their folders were clearly not interested at all and the small group of boys working out the areas of rectangles were not working with enthusiasm.

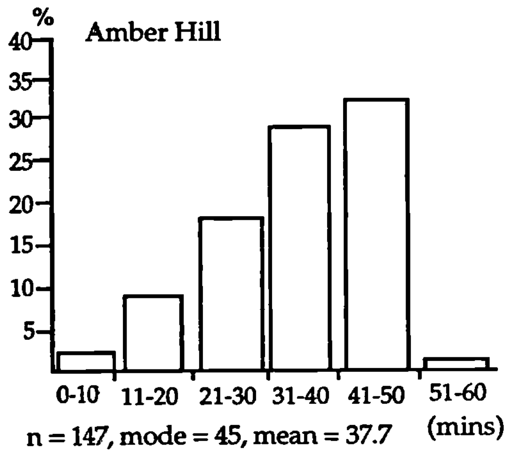
An important difference between Amber Hill and Phoenix Park was that Phoenix Park students were not made to work. In interviews the students did not talk about work that they had done because they had been forced to, but that they had gained little from, in the way that the Amber Hill students did. They talked instead about the choice they had between involvement and doing nothing:

> H: It was definitely a lighter lesson - you'd be involved and if you didn't want to be involved you'd sort of sit back and watch it all happen I suppose. (Hannah, PP, year 11, JC)

Here Hannah does not give working without involvement as an option, whereas this was something the Amber Hill students were very aware of. The freedom the students experienced to work when they wanted to work meant that some students did very little in lessons, but it also meant that some student worked in a very motivated way. When students were asked to say the amount of time they worked in lessons the results were interesting. I have presented, below, the Phoenix Park students' results alongside those of the Amber Hill students to demonstrate the difference in the shape of the two graphs. At Phoenix Park the students' times fell into an almost perfect 'normal distribution' shape, indicating that when students were given the freedom to work (or not), some students did very little work but equal numbers chose to do a lot. Indeed a much greater proportion of Phoenix Park students reported working for 51-60 minutes than Amber Hill students who were 'made' to work (12% at Phoenix Park, 2% at Amber Hill). Despite these differences the means of the times given by Amber Hill and Phoenix Park students were identical (37 minutes). This, in some senses, is remarkable given the difference in the freedom experienced by the two sets of students. In chapter 5 I described the relaxed nature of Jim Cresswell's lessons and said that these lessons appeared to be more chaotic than those of Martin and Rosie and that the head teacher had complained to Jim about this. The means of the times given by students of the three teachers at Phoenix Park were as follows: Rosie 40 minutes, Jim 39 minutes, Martin 32 minutes. Martin was reported by the students to be the strictest of the three teachers. The similarity between the times given by students of different teachers and the times of students at the different schools adds further weight to the idea that making students work is not a particularly effective way of getting students to think about mathematics.

Figure 6.2 Students' perceptions of time spent working at Phoenix Park and Amber Hill





b) The uninterested students

In every mathematics lesson I observed between three and six students would do very little work and spend much of their time disrupting others. I shall now try and describe the motivation of these twenty or so students, who represented a small but interesting group. The students who did very little work in class were mainly boys and they related their lack of motivation to the openness of the mathematical approach and, more specifically, the fact that they were often left to work out what they had to do, on their own.

> S: I tend to doss about a lot in maths, half the time I can't be bothered to call miss over or ask her what I want to know, but I do realise that maths GCSE is pretty important.
> JB: Why do you mess about in maths more than other subjects?
> S: Because half the time if I ask for help I don't get it, or I don't get it until twenty minutes after I've asked. (Shaun, PP, year 10, RT)

Many of the students at Phoenix Park talked about the difficulty they experienced working on open projects that required them to think for themselves, when they first started at the school. But most of the students gradually adapted to this demand, whereas the disruptive students continued to resist it. In years 10 and 11 I interviewed six of the most disruptive and badly behaved students in the year group, five boys and one girl. They explained their misbehaviour in lessons in terms of the lack of structure or direction they were given and, related to this, the need for more teacher-help. These students had been given the same starting points as everybody else but, for some reason they seemed unable, or unwilling, to think of ways to work on the activities without the teacher telling them what to do. This was a necessary requirement with the Phoenix Park approach, for it was impossible for all of the students to be reliant on the teacher helping them when they needed to make decisions. Kevin and Jake were two of the most badly behaved boys in one of Jim Cresswell's groups:

> K: He'll set a task and he'll write it on a piece of paper and then he'll give you a little example of what you've got to do and then he'll just give it to you and he'll tell you to get on.
> J: Yeah, so you don't understand.
> K: Like you'll sit there and you're reading it and you're trying to work it out and you ask him for help and he'll say he's doing something or he's over helping someone else or something.
> JB: Do you think that while you're working it out for yourself that is helpful, or would you rather be told?
> K: I'd rather be like, I don't want to be told like everything, the answers, I just want to be told how to start and you can just work on from then. But he just says read the sheet and you read it and it doesn't make no sense to you, but if he'd like tell it out to you then it'd be easier. (Kevin & Jake, PP, year 10, JC)

The students who did not work in lessons were not of a lower ability than other students, they did not come from the same middle school and they were not from a certain socio-economic group. In questionnaires the students did not respond differently to other students, even on questons designed to assess learning style preferences. The only aspect that seemed to unite the students was their behaviour and the fact that most of them were boys. The reasons that some students acted in this way and others did not were obviously complex and due to a number of inter-related factors. One of the factors that seemed to be important was the sex of the students. Martin Collins believed that more of the boys experienced difficulty with the approach because they were less mature and they were less willing to take responsibility for their own learning than the girls. Some of the girls offered similar explanations:

N: If you like maths and you care about doing it then you can do really well, but some people in our class just used to mess about, they never used to do anything, they never even handed in their projects.
JB: Why was that do you think?
N: They were too into, just being idiots, jumping around the class and giving up and annoying everyone else.
JB: That was more interesting to them?
P: Yes, it was mostly the boys.
JB: Why were the boys like that do you think?
P: They don't care do they really?
J: They just look at it, get confused and start messing about.
N: They don't care about their work, they think there are more important things, you can tell that from my brother whose a year younger than me, he's an idiot. (Pauline, Nicola and Janet, PP, year 11, RT)

The idea that the boys were badly behaved because of immaturity was also partly validated by the improvement in the boys' behaviour as they got older:

I: We have wasted a lot of time in the lessons, some of it, we have wasted time.
G: Yeah, we didn't used to do any work in lessons at all.
JB: But you take it more seriously now?
G: Yes.
JB: Why?
G: I'm not sure, in maths, then, we used to...
I: Chuck stuff.
G: Yeah we always used to be chucking stuff and fighting, now we're a bit more serious. (Gary & Ian, PP, year 11, JC)

Most of the disruptive students related their behaviour to the mathematics approach and the lack of help from the teacher, others said that they enjoyed 'messing about' and they gained more satisfaction from this than they did from working:

S: When I go into a maths lesson I usually sit down and I think - who am I going to throw a rubber at today? (Shaun, PP, year 10, RT)

JB: Can you think of a maths lesson that you've enjoyed?

M: Messing about, that's what I enjoy doing. (Megan, PP, year 10, RT)

The misbehaving students in each group were generally street-wise, confident students, who seemed to enjoy being the centre of attention. It was as if they had decided that school work was not for them, but they could gain satisfaction and self-esteem from being part of an anti-school sub-culture. Other research studies have shown the presence of students with anti-school values who gain pleasure from misbehaving (Willis, 1977; Ball, 1981), but the Phoenix Park students experienced more freedom than students generally do in schools. The result of this freedom seemed to be that they did very little work. The students were also required to do a lot in mathematics lessons. They were not asked to work through pages of a book, following a rule, they had to think for themselves and plan their work. They needed to make decisions and co-ordinate strategies. For many of the students, who were probably more inclined to 'mess about' than work when they arrived at the school, this was too much.

JB: So, do you think because you are left to motivate yourselves, do you think that's a bad approach for the boys?
P: Yeah they never did much work at all.
N: Yes, because the boys need to be told, you have to give them something to work out, so they know what to do on it. (Pauline & Nicola, PP, RT, year 11)

H: Well I don't think they were stupid or anything they just didn't want to do the work, they didn't want to find things out for themselves, they would have preferred it from the book, they needed to know straight away sort of thing. (Helen, PP, year 11, MC)

The bad behaviour and lack of motivation from these students seemed to relate to at least three features of their mathematics lessons. First of all, the *demand* being placed on the students seemed to increase their resistance to work as well as their inclination to 'mess about'. As the girls said, they 'didn't want to find things out', they 'would have preferred it from the book', they 'needed to be told'. Second, the freedom the students experienced to do what they wanted to in lessons gave them the *opportunity* to behave badly and do no work. Third, the lack of structure the students were provided with, from the teacher or the materials, gave them the perfect 'excuse', they had a reason which made them feel justified in doing no work. These features combined with other more complex student characteristics and behaviours to influence the students' responses to lessons.

The groups at Phoenix Park who did very little work in lessons were distinct from other students at the school, but their behaviour in lessons was only a more extreme version of a behaviour which was prevalent amongst most students at some times during lessons. The students worked when they wanted to work, which, for most students, meant intermittently.

> S: But the tables that don't, even the tables that do get on with their work tend to jabber on a bit, like, Miss Thomas goes over to the table and she'll say "Oh did you see Neighbours last night?" to the other table and then they'll start talking and everyone will be talking. (Shaun, PP, year 10, RT)

To summarise, it is probably fair to say that the students at Phoenix Park spent less time working than the students at Amber Hill, but more time engaged in their work. This was not true for all of the students, but the widespread lack of interest that was evident at Amber Hill was rarely witnessed at Phoenix Park. This was replaced by a much more varied response to work, which, for most students, included times of involvement and times of non-mathematical activity.

6.3.3 Students' views about the nature of mathematics

The students at Phoenix Park were very different from the students at Amber Hill in the way that they viewed mathematics. This was because most of the students believed mathematics to be an active, enquiry-based discipline. In the year 10 questionnaire item that asked students to prioritise either thought or memory, 65% of students at Phoenix Park chose thought, this compared with 36% of Amber Hill students. The students did not see mathematics as a rule-bound subject involving set methods and procedures that they needed to learn, they saw it as a subject of explorations, negotiations and enquiry:

> A: You explore the different things and they help you in doing that. (Alex, PP, year 11, JC)

> P: You can do it at your own level, what suits you, and it's very sort of open. You can use it in different ways, you can do different things more than with set questions.
> S: You're able to explore, there's not many limits and that's more interesting. (Philip & Simon, PP, year 11, JC)

The students also had a sense of mathematics as a subject that allowed them to think deeply, to go beyond surface features of questions:

> V: I thought the activities were more interesting.

L: Yeah the activities.

JB: What do you think of the stuff you're doing now? (year 11 examination preparation)

V: It's just basically going back over through the stuff we learned through the activities but it's boring, it's more straight forward now.

JB: Do you think the activities weren't straightforward?

V: Some of them weren't, you had to work out for yourself what was going on, you had to use your own ideas more. (Lindsey and Vicky, PP, year 11, JC)

P: It's when you like learn new ways of doing things or you're like doing quite well on a problem... you're taking it really far, the investigation, you're getting really deep into it.. you feel like you're learning quite a lot more. (Philip, PP, year 11, JC)

There is evidence that many students regard mathematics to be a collection of procedures that allow them to answer questions in a short space of time (Schoenfeld, 1988). The Phoenix Park students did not seem to have this shallow view of mathematics, they were aware of the depth of the subject, the different layers that may be encountered. The students also demonstrated an unusual awareness of the diversity and breadth of mathematics. They did not regard mathematics as a vast collection of sums, they seemed to have a richer and more balanced view of the subject:

A: I used to think that maths was just sums and hard work.

JB: Don't you now?

A: No, not really, some of it is, but there's a lot more stuff involved in it as well.

JB: What other stuff?

A: Well, different sorts of - well there's loads of different things, theories and stuff like that, formulas, algebra, shapes and stuff. (Alex, PP, year 11, JC)

JB: Has doing the projects changed the way you think in any way?

D: Yes 'cause like bookwork - say it's just all sums or whatever, but that's only like one really small part of maths isn't it?

JB: Mmm.

A: If you're doing all problems and that you can learn about all the different areas. All the really advanced maths is a lot more to do with theorems and theories and that sort of thing than just sums. (Danny & Alex, PP, year 11, JC)

Neither Danny nor Alex particularly liked mathematics, compared to their other school subjects, but this did not appear to affect the way in which they constructed their views about the *nature* of mathematics. Both students showed that they regarded mathematics as a diverse subject in which 'sums' were 'only one really small part'. In their year 9 questionnaire students were asked to describe one or more situations when they had used mathematics outside of school. Seventy seven per cent of the Amber Hill students' comments related to money or shopping and no descriptions were given of situations requiring the use of data handling, shape or space. At Phoenix Park 53% of comments also related to money and shopping but 14% of students described non numerical activities such as sorting out a magazine collection, classifying option choices at a club, laying slabs in the front garden, organising a bank account, reading a map and organising a route for a paper round. These were not examples that the students had been told about in class or contexts they had encountered in lessons.

The discourse that the Phoenix Park students used to describe mathematics at various times was always very revealing. The students' conversations with me and with each other, in interviews and lessons, revealed a language of exploration, of predictions and discoveries:

> L: The projects, we used to do, like we made a bridge out of paper.
> H: You had to work it out, say how much load each bridge could take and by the end of it you'd have learned things, you'd be making it and saying 'oh I predicted wrong' sort of thing. (Louise & Hannah, PP, year 11, JC)

> J: We discuss things in maths, we compare and discuss our results. (Julia, PP, year 10, RT)

> I: It's an easier way to learn because you're actually finding things out for yourself, not looking for things in the textbook. (Ian, PP, year 10, RT)

In many of my lesson observations the students approached mathematics and talked about mathematics in ways that were qualitatively different from most students I have observed in mathematics classrooms. The following extract is taken from a year 11 lesson with Martin Collins:

> Anne and Cathy go up to MC's desk and say 'Our hypothesis was right sir' he says 'Uh huh' Anne continues 'Yes we predicted a rule for the number of dots, we tried it out on 3, no 4 cases and it worked every time' Cathy adds 'And we can tell it's right from the way that it works'. (Martin Collins, year 11)

These students were working on a fairly standard investigation, what is interesting about their interaction with Martin is that they did not use the common language of mathematics classrooms. They did not say 'sir we've done it, we've found the rule' or the answer. They talked about their hypotheses, they signified the importance of the testing process and they showed that they had thought about the procedure they used as a validation of their hypothesis. Students often showed that they were not only interested in the answers to the investigations and problems they worked on. They were aware of the importance of the methods and processes which they used along the way:

> P: Sometimes I can't really think how things can be used, but it's the process and the method, I suppose, and the way you look at it. (Philip, PP, year 11, JC)

In one of my lesson observations I read part of Sam's write up of *36 fences*. Sam was a low 'ability' girl, she had written:

> The biggest triangle was 12 x 12 x 12, the biggest rectangle was 9 x 9, next I drew a regular hexagon and regular octagon, the octagon had a larger area than the hexagon. I thought about these things and I now think that the regular shape always has the largest area, although I haven't proved it. I also think that the more sides the pen has the larger the area, so a 36-sided pen would have the largest area.

In this extract Sam shows that she is not only concerned about finding answers and although the description of her work is brief, she conveys the processes she went through in arriving at her two conclusions. She also notes that she hasn't proved her theories which indicates both that she is aware that one or two examples do not constitute a proof and that the theories or answers that she has arrived at only form part of the story.

The students' awareness of the methods and processes they used in their work can probably be related back to the encouragement their teachers gave them to think about methods and strategies. Students were often asked to think about what they had been doing in lessons and to plan the direction of the rest of their work for homework. These homeworks stand in direct contrast to the more typical 'finish up to question 20' mathematics homework. They explicitly required students to think about strategies and methods. In this extract Rosie Thomas is talking to John who has just solved a problem:

> RT looks at John's work and says 'Brilliant work John', then 'but you can't just write it down, there must be some sense to why you've done it, some logic, why did you do it that way?, explain it.' (Rosie Thomas, year 10)

Rosie's 'there must be some sense to why you've done it' typifies the sort of encouragement the students were given at Phoenix Park. The teachers strove to *expand* the way in which the students thought about mathematics. They tried to extend their value systems beyond the desire to attain correct answers. There were many indications that the teachers were successful in this regard and that the unusually dynamic views the students held about mathematics were formed in response to their project based work. All of the students contrasted this work with the SMP bookwork they did in middle school and the examination revision of year 11. For some students the main difference between SMP mathematics, which they studied in years 7 and 8, and the projects at Phoenix Park was the diversity of mathematics they encountered. This was interesting because SMP booklets do cover the full breadth of the national curriculum, with booklets on shape and space and data handling, as well as number and algebra. But the students talked about their SMP work in terms of numbers and sums. In the following interview extracts I have asked the students to describe to me the mathematics they used to do in middle school:

> I: We used like textbooks all day and you had to like do all these sums. (Ian, PP, year 10, RT)

> J: We were working from books then.
> H: Yeah and it was more like, just adding and timesing weren't it?
> JB: When you say it was more adding and timesing what do you mean?
> H: Well in our middle school it was just like - add these numbers together or times them or whatever, but now we're doing like percentages and estimating things and all sorts of things. (Julia & Helen, PP, year 10, RT)

The students also talked in similar terms to the Amber Hill students about the monotony of SMP work:

> H: It's more interesting now, you're not just working through a book doing the same things.
> JB Did you just work through books all the time before?
> H: Yes when you'd finished one book, you'd be put onto, like a harder book. (Helen, PP, year 10, RT)

> S: The work's not quite so technical here, you can sort of do a lot more, sometimes the topics - you can choose which way you want to go but at my old school it was all set work and you had to do certain things to complete the task which isn't as good. (Shaun, PP, year 10, RT)

S: You go right through the pages of a book until you've finished it and then it takes you to other pages, all pretty much the same stuff, you can't really experiment with work in books. (Shaun, PP, year 10, RT)

L: It gives you more freedom here and it lets you find things out for yourself, where a book would just give you all the answers and stuff and you wouldn't have to find things out for yourself, you have to find things out for yourself and its more interesting and I think you tend to remember it more when you've found things out for yourself. (Louise, PP, year 11, JC)

They also talked about the need to focus on methods and processes within their project work:

T: We sort of explain more now, we can put our methods down and what you think. (Tanya, PP, year 10, MC)

I: If you got an answer they would say you got it right, here you have to explain how you got it. (Ian, PP, year 10, RT)

The students at Phoenix Park had all experienced a book-work approach to mathematics prior to their project-based work and the contrast they offered between the two approaches focused upon the more dynamic nature of the mathematics they encountered in their project work. They talked about the way that books did not give them anything to 'find out' or 'explore', they merely gave them 'set work' that they had to 'work through'. The students highlighted the *procedural* aspect of bookwork which, they said, made mathematics less interesting and useful for them.

The significance of the students' project work to the active views of mathematics that they had developed was also demonstrated by the results of their year 10 questionnaire. At Phoenix Park the students worked in an entirely open way until Christmas of year eleven when they started preparing for examinations. At this time the mathematics approach became considerably more closed and the students were introduced to rules and formal methods and structures. The questionnaire taken by students in years 9, 10 and 11, when my case study year group were in year 10, included the question that asked students to prioritise either thought or memory. Sixty six per cent of students completing year 9 and 65% of students completing year 10 thought it was more important to think hard about questions, than remember similar questions. This proportion fell to 48% of students completing year 11. At another point in the questionnaire the students were asked to rank different areas of mathematics in terms of importance. Five per cent of year 9 students and

8% of year 10 students thought that 'remembering rules and methods' was the most important part of mathematics, in year 11 this increased to 17% of students. Responses to the same questions given to three year groups at Amber Hill remained constant between the three year groups (17%, 15%, 15%).

The Phoenix Park students' responses to their year 11 examination preparation, also shown in chapter 8, indicate that the change from project work to a more formal mathematics approach prompted a corresponding change in the students' views about mathematics. This was also demonstrated by the change in the students' views about mathematics and mathematics lessons that were reported in questionnaires given to them in years 10 and 11 (see appendices 8 and 9). Cobb, Wood, Yackel & Perlwitz (1992) also found this to be true of students who worked on projects and who then reverted to a textbook approach. This caused many more of the students to think that success in mathematics involved following a teachers' set methods. At Phoenix Park the project based approach had expanded the students' views of mathematics and caused them to regard mathematics as an active, exploratory discipline, the examination work caused students to go back to some of their old views about the limited nature of mathematics, thus eradicating some of the school's positive achievements.

6.3.4 Independence and creativity

The students at Phoenix Park were encouraged in many different ways to be independent in mathematics, mainly through the degree of choice they were given and the responsibility they needed to take for their work. In their year 10 questionnaire students were asked to describe mathematics lessons and 11% of students chose to comment upon the independence they experienced in their lessons. For example, 'what you do is mostly up to the pupils'. When teachers interacted with students they treated them as though they were equals. If they asked students to do something and the students asked why, they would explain rather than say 'because I said so'. The teachers did not seem to try and gain respect or deliberately distance themselves from students and the gap between teachers and students was not distinct. This seemed to have a direct effect upon the students. When they interacted with adults, even strangers, they were confident and chatty, they never appeared to be nervous, or even particularly respectful:

> MC starts writing on the board '28 pounds are to be divided up between Carla and Claire in the ratio 3:4' MC asks if anybody knows how much they would get each. (MC always uses the names of his class in his examples). John calls out two numbers but he is wrong, MC says 'OK there are seven shares so how much is each share worth?' Lisa

calls out '28 + 7', MC says 'which is?' Lisa says '4'. MC goes over the process again and asks 'Is everybody comfortable with that idea?' The class all say that they are. At this point Carla starts talking loudly, MC asks her to be quiet, she says 'OK darling, sugar, sexpot'. MC says 'don't you darling me' in a friendly tone and continues. (Martin Collins, year 11)

The class start their work and Paul needs a ruler. There are a pile of rulers on the desk but Paul doesn't go and get one, he says 'Miss with your sweet Bristol accent, will you give out the rulers please?' (Rosie Thomas, year 10)

When visitors walked into the classrooms at Phoenix Park, which was a common occurrence, the students appeared to be unconcerned whether they were inspectors, visiting dignitaries or parents. They would always chat to adults, run around, misbehave or swear at each other in the same relaxed manner, whoever was with them. When the head teacher walked into lessons the students would not change their behaviour in any way and those who were not doing work would continue not to do work. In many of my conversations with students and observations of them around the school I was often reminded of Neill's (1985) Summerhill students. Neill attributed the confidence and ease with which these students treated adults to the progressive approach of Summerhill school which, he claimed, took away their fear and oppression (Neill, 1985).

The independence encouraged in the Phoenix Park students extended to the way in which they organised themselves in lessons. The following extracts are taken from Martin Collins' and Jim Cresswell's lessons:

Whilst MC is helping a student the rest of the class realise that it is 10.40 (break time), they all pack up and wander out of the room. MC does not seem to notice or mind, he continues helping Hayley, Hayley does not seem to be bothered that it is now break time. (Martin Collins, year 11)

A group of boys are sitting talking and haven't started any work. Two girls working near them get up and take their work to the maths office upstairs, I think they are fed up with the noise the boys are making. They don't ask, they just go. (Jim Cresswell, year 10)

The students' independence also affected the way in which they approached their work:

The students are working on different projects and Leah asks 'Sir, can you give me some help so that I can move forward with my coursework?', MC wanders over to her table and chats to her. While he is there Carla gets a CD out of her bag and starts reading it, MC asks her to put it away, she says 'I know, but I'm not interested in this bit of work' MC wanders away. Ten minutes later he goes back to Carla and asks her if she would like to do a different activity 'where she has to use her creativity and imagination', Carla says she would and MC suggests that she 'investigates the admission policy of the school's workplace nursery'. (Martin Collins, year 11)

The independence and responsibility encouraged in the students seemed to have a direct effect upon their approach to mathematics. In a general sense the students seemed less oppressed and constrained than many students of mathematics and they seemed to take a more creative approach to mathematics than was normal for school students. In a questionnaire given to the students in year 11, 82% of Phoenix Park students agreed with the statement: 'It is important in maths to use your imagination', this compared with 65% of Amber Hill students, which was a significant difference (χ^2 = 6.6, d.f. = 1, $p < 0.02$). The students' creative approach to mathematics was demonstrated by the applied 'Planning a Flat' activity I gave the students in year 10. In this activity the students were asked to design a flat in a given space and locate and draw the furniture in their flat. A major, but unexpected, difference between the students at Amber Hill and Phoenix Park related to the designs students produced. The students were invited to design a flat to suit a person or people of their choice, for example, a student, a couple, a family or themselves. The choice of rooms they would have in the flat was left entirely up to the students. All of the students in both schools included in their designs at least one bedroom, bathroom, living room and kitchen. However, approximately one-third of the Phoenix Park students also included more unusual rooms. In the 89 designs produced by the students at Phoenix Park there were 35 examples of 'unusual' rooms with: 7 games rooms, 4 football rooms (generally including small 5-a-side pitches), 3 indoor swimming pools, 3 study's, 2 hi-fi rooms, 2 children's playrooms, 2 cocktail bars and one each of a bouncy castle room, a pool room, a Jacuzzi, a computer room, a gym, a garage, a bowling alley, a utility room, a piano room and a disco room. At Amber Hill there were 99 flat designs which included 2 pool rooms, 2 swimming pools, 1 playroom and 1 store room. At Phoenix Park the students included the rooms that they wanted to have in their flats, at Amber Hill the students included the rooms that they thought that they should have, the rooms that a teacher or I would approve of.

The lack of constraint the Phoenix Park students experienced in these different domains, and the lack of domination or control that was imposed by teachers seemed to have contributed towards the confidence of the students at Phoenix Park, the creativity they demonstrated and the relaxed way in which they appeared to make and take decisions:

A: That's the way I am... I just kind of do things in my own way, if it pulls off, it pulls off, if it doesn't then that's down to me. (Andy, PP, year 11, RT)

6.4 Further comparisons of Amber Hill and Phoenix Park

The students' responses to their mathematics teaching that have been considered so far give some indication of the different effects that the two approaches had upon students' perceptions and behaviours. In this section I would like to present some more evidence for differences between the students at the two schools using some questionnaire results that have not been presented before. These concern enjoyment, the nature of mathematics and gender differences.

When students were asked to state how often they enjoyed the mathematics they did in school in their year 9 questionnaire, similar *quantitative* results were received from the two schools. Forty three per cent of Amber Hill students and 52% of Phoenix Park students reported enjoying mathematics 'always' or 'most of the time'. However, the students responded very differently to open questions on the same questionnaire, indicating that the closed questions may have been less effective at eliciting the students' real feelings. One question asked the students to describe what they disliked about mathematics at school and 44% of Amber Hill students criticised the mathematics approach, and 64% of these students criticised the textbook system. At Phoenix Park 14% of students criticised the school's approach and the most common response, from 23% of students, was to list nothing they disliked about mathematics at school, this compared with 6% of Amber Hill students. Table 1 presents all of the responses the students gave to the 3 different, open questions on the questionnaire which asked students what they liked, disliked and would like to change about mathematics lessons. These 3 questions prompted 382 comments from the 160 Amber Hill students and 202 comments from the 103 Phoenix Park students. The responses have been combined in order to present an overview of the issues important to the students.

Table 6.3: Year 9 open questionnaire responses

	Amber Hill % (from n = 382)	Phoenix Park % (from n = 202)
Enjoy open-ended work	14	38
Dislike textbook work	22	0
Can't understand work	20	6
Can understand work	3	5
Work is interesting	4	21
Want more interesting work	15	19
Want more group work	5	0
Enjoy working alone / with others	8	4
Pace is too fast	9	3
Pace is about right	0	3

One of the most obvious differences which is demonstrated by these results is that when students were invited to give their own opinions about mathematics lessons, the Phoenix Park students chose to comment upon the interest of their lessons and their enjoyment of open-ended work, whereas the Amber Hill students were more concerned about lack of understanding and their dislike of textbooks. Many more of the Amber Hill students would probably have talked about open-ended work if they had ever experienced any, but at that time they had not yet worked on their coursework projects. In response to the three questions above there were a total of 88 comments from Amber Hill students about their perceived lack of understanding of mathematics, this compared with 6 comments from the Phoenix Park students.

Probably the greatest difference that existed between the students at the two schools related to their views about the nature of mathematics. These were most clearly demonstrated by the students' descriptions given in interviews, but some of their responses to questionnaire items also demonstrated the different perceptions the students had developed. In the year 10 questionnaire when students were asked whether it was more important when approaching a new problem, to think or to remember, 64% of Amber Hill students prioritised remembering, compared with 35% of Phoenix Park students. This, in many ways, demonstrates the most important differen e between the views of the two sets of students. In the same questionnaire the students were asked to rank the importance of: working at a fast pace, getting a lot of work done, remembering rules and methods, understanding work and knowing how to use a calculator. Significant differences occurred on this question: 15% of Amber Hill students and 8% of Phoenix Park students stated that remembering rules and methods was the most important part of learning mathematics ($\chi^2 = 9.7$, d.f = 4, $p < 0.02$) and 57% of Amber Hill students compared with 29% of Phoenix Park students considered that knowing how to use a calculator was one of the three most important aspects of mathematics ($\chi^2 = 24.5$, d.f. = 4, $p < 0.001$).

In a questionnaire given to students in year 11, significantly more Amber Hill students agreed with the following statements:

• most of maths is just repeating the same sort of thing over and over again, Amber Hill = 62%, Phoenix Park = 44% ($\chi^2 = 6.2$, d.f. = 1, $p < 0.02$).
• it is important in maths to get more things right than other people, Amber Hill = 22%, Phoenix Park = 9% ($\chi^2 = 4.9$, d.f. = 1, $p < 0.05$).

Whereas significantly more Phoenix Park students agreed with the statements:

• it is important in maths to find your own way of solving problems, Amber Hill = 73%, Phoenix Park = 88% ($\chi^2 = 5.6$, d.f. = 1, $p < 0.02$).
• it is important in maths to use your imagination, Amber Hill = 65%, Phoenix Park = 82% ($\chi^2 = 6.3$, d.f. = 1, $p < 0.02$).
• it is important in maths to think about different types of maths, Amber Hill = 78%, Phoenix Park = 92% ($\chi^2 = 6.2$, d.f. = 1, $p < 0.02$).

Another important difference between the two schools related to gendered preferences for ways of working. In questionnaires given to students in years 9, 10 and 11, the boys were always more positive and confident than the girls at Amber Hill, and most of these differences were statistically significant. There were rarely any significant differences between girls and boys at Phoenix Park. These differences, which will be discussed in more depth in chapter 9, continued throughout years 9, 10 and 11.

6.5 Discussion and Conclusion

The students' responses to their textbook teaching at Amber Hill were consistent and fairly unanimous. Some of the students were content with their mathematics teaching and with the safety and structure of working through books every lesson, but the majority of students reported that they found this work boring and tedious. Most students preferred their coursework, partly because it was a change, but also because it gave them the opportunity to think about their work and use their initiative. The students valued this type of work because they felt that they gained understanding from it and this contrasted with what they felt they gained from textbook lessons. The students' behaviour when working through textbooks was consistent with these perceptions: they showed a marked degree of uninterest and uninvolvement, they reported 'switching off' as soon as lessons started and they worked procedurally without giving thought to what they were doing. The students wanted to understand more than they did and this was revealed by their preferences for working at their own pace, which they felt gave them access to a deeper understanding and time to think about what they were doing. Not surprisingly their fast, structured and uniform experiences of mathematics had clear and obvious consequences for the mathematical views they developed. The students regarded mathematics as a rule-bound subject and they thought that mathematical success rested on being able to remember and use rules. They thought that it was more important to remember similar work than to think about what to do and they rarely tried to interpret situations mathematically, because they had learned to recognise SMP cues and choose procedures and rules accordingly.

At Phoenix Park the students differed from the Amber Hill students on all of these counts. They did not believe lessons to be uniform and monotonous. Instead they regarded their lessons as varied and their enjoyment of lessons depended upon the particular activities they encountered. The students also displayed varied levels of engagement which differed between students as well as between lessons and parts of lessons. A small but important proportion of the year group at Phoenix Park misbehaved in lessons and said that they did not like the school's approach. However, it was difficult to know whether the students' lack of motivation caused their negative views about mathematics, whether it was the other way around or whether there was no causality involved.

Many of the Phoenix Park students regarded mathematics to be a dynamic, flexible subject that involved exploration and thought. They valued the importance of mathematical processes and the views they developed were, according to a wide range of literature (Erlwanger, 1975; Doyle, 1983; Schoenfeld, 1988) extremely unusual. Additionally, the students displayed a freedom, creativity and lack of constraint in their interactions and behaviours which appeared to derive directly from the approach of the school.

In the next chapter I shall present the results of various different assessments and consider the way in which the difference between the two schools' approaches affected the students' understanding of mathematics.

Chapter 7 The Students' Understanding of Mathematics

7.1 Introduction

At both Phoenix Park and Amber Hill school the students spent three hours in their mathematics classrooms each week and the aim of this chapter is to provide an evaluation of the learning that took place during this time. In order to acknowledge the complexity of the learning process and the variety of different forms of mathematical knowledge and understanding that may be developed, this account will draw upon a range of different assessments which the students undertook at various points during the three years.

The different assessment instruments used during the study were designed in order to investigate whether the different school approaches had a differential impact upon:

- the students' development of mathematical knowledge and understanding
- the capability or willingness of students to make use of mathematics in new and different situations
- the length of time students could make use of the mathematics they had learned

The following table provides an overview of the different research assessments that were used with students at different points in time and the main purpose of each assessment:

Table 7.1 Research Assessments Overview

Timing	Form of assessment	Students involved	Research aim
beginning of Y9	7 contextualised, short questions	all year group in both schools n = 305	to provide information on mathematical knowledge, use of mathematics in different contexts & a base-line measure of the students' performance at the start of the research period
end Y9	architectural activity & related tests	half of 4 groups in each school n = 104	to provide information on the students' use of mathematics in an applied activity and their use of the 'same' mathematics in a short test
mid Y10	long-term learning tests	2 groups in each school n = 61	to assess the students knowledge of mathematics before it was taught, immediately afterwards and 6 months later
end Y10	9 contextualised, short questions	all year group in both schools n = 268	to provide information on mathematical knowledge, use of mathematics in different contexts & changes in performance between Y9 & Y10
end Y10	flat design & related tests	4 groups in each school n = 188	to provide information on the students' use of mathematics in an applied activity and their use of the 'same' mathematics in a short test
end Y11	analysis of GCSE answers	all GCSE entrants in each school n = 290	knowledge of mathematics, analysis of use of mathematics in conceptual / procedural questions

In the next section I will present the results of each of these assessments in the approximate order in which the students took them.

7.2 Assessment Results

7.2.1 Year 9 context questions

a) Results

At the beginning of year nine all of the case-study year group in each school were given a series of short questions, given in appendix 10. A total of 305 students took these questions, 195 students from Amber Hill and 110 from Phoenix Park. The seven questions were intended to give a measure of the comparability of the students at the two schools at the beginning of the research period. Three of the questions assessed fractions, two of the questions presented a conservation of number problem and another two questions required the students to put numbers into groups. The same mathematics was presented in different contexts in order to assess the extent to which students would vary their use of mathematics across contexts. All of the students' answers were given a grade from 1 to 4 according to assessment criteria which are given in appendix 18. The results of the seven questions for the two schools are given below:

Table 7.2 Y9 Chocolate splits

Grade	AH (n)	PP (n)	AH (%)	PP (%)
1	96	45	49	41
2	83	59	43	54
3	15	5	8	5
4	1	1	1	1

$\chi^2 = 3.64$, d.f. = 2, $p < 0.20$[1]

Table 7.3 Y9 Tug of war

Grade	AH (n)	PP (n)	AH (%)	PP (%)
1	95	47	49	43
2	85	61	44	47
3	10	1	5	1
4	5	1	3	1

$\chi^2 = 1.01$, d.f. = 1, $p < 0.50$[2]

[1]performed on collapsed table with categories 3 & 4 combined
[2]performed on collapsed table with categories 2, 3 & 4 combined

Table 7.4 Y9 Cutting Wood

Grade	AH (n)	PP (n)	AH (%)	PP (%)
1	113	60	58	55
2	38	31	19	28
3	33	14	17	13
4	11	5	6	4

$\chi^2 = 3.44$, d.f. = 2, $p < 0.20$[3]

Table 7.5 Y9 Fashion Workshop

Grade	AH (n)	PP (n)	AH (%)	PP (%)
1	111	65	57	60
2	45	25	23	23
3	21	13	11	12
4	18	7	9	6

$\chi^2 = 0.84$, d.f. = 3, $p < 0.90$

[3]performed on collapsed table with categories 3 & 4 combined

Table 7.6 Y9 Penalties

Grade	AH (n)	PP (n)	AH (%)	PP (%)
1	5	7	3	6
2	6	1	3	1
3	182	101	96	92
4	2	1	1	1

$\chi^2 = 0.32$, d.f. = 1, $p < 0.70$[4]

Table 7.7 Y9 Plants

Grade	AH (n)	PP (n)	AH (%)	PP (%)
1	3	4	2	4
2	5	2	3	2
3	183	100	94	91
4	4	4	2	4

$\chi^2 = 0.29$, d.f. = 1, $p < 0.70$[4]

[4]performed on collapsed table with categories 1 & 2 and 3 & 4 combined
[5]performed on collapsed table with categories 1 & 2 and 3 & 4 combined

Table 7.8 Y9 Fractions

Grade	AH (n)	PP (n)	AH (%)	PP (%)
1	2	4	1	4
2	14	6	7	5
3	162	89	82	81
4	17	11	9	10

$\chi^2 = 0.23$, d.f. = 2, $p < 0.95$[6]

[6]performed on collapsed table with categories 1 & 2 combined

These results show a marked degree of similarity in the performance of the students at the two schools, with almost identical proportions of students attaining each grade and no statistically significant differences on any question. Appendix 19 also shows the performance of students cross-tabulated for each pair of questions assessing the same area of mathematics and the percentage of students who attained the same grade on each pair of questions. These results also show almost identical patterns of performance at the two schools.

b) Discussion

The results of these questions give some indication that the students had a similar mathematical knowledge and understanding at the beginning of year 9. This idea was also supported by the similarity in the students' NFER test scores taken at the beginning of year 9 and shown in chapter 2. The similarities between the students at this stage reflect, in part, the fact that both sets of students had been taught mathematics using the SMP scheme in years 7 and 8.

7.2.2 Authentic activities and related tests

a) Introduction

Previous research has established that individuals use different forms of mathematics in school and real-world situations, because they do not perceive the demands of these different situations as similar (Masingila, 1993; Nunes, Schliemann & Carraher, 1993; Lave, Murtaugh & de la Rocha, 1984). I was not able, in this research study, to observe the students' use of mathematics in out-of-school situations, but I designed two different 'authentic' activities in order to provide situations with a mathematical demand that was similar to that of real world situations. For example, in the two activities, the students needed to find information from different sources, choose their own methods, plan routes though the tasks, combine different areas of mathematical content and communicate information. The way in which students responded to these activities could not be taken as an indication of the way in which they might respond to real situations outside of school. However, the activities provided the opportunity for me to see whether students would be able to make use of school learned mathematics within tasks that they were not used to. At Amber Hill the students were not used to activities that did not tell them the precise method to use or to situations that required the use of different forms of mathematics combined together. At Phoenix Park the students were not used to completing tasks with a set objective within a specified and relatively short length of time. The applied activities were more similar to the Phoenix Park students' normal school work than the Amber Hill students' work, but both sets of students were also given a short written test of the same areas of mathematics that were assessed in the activities. This enabled a comparison of test performance with activity performance for both sets of students.

b) The architectural activity

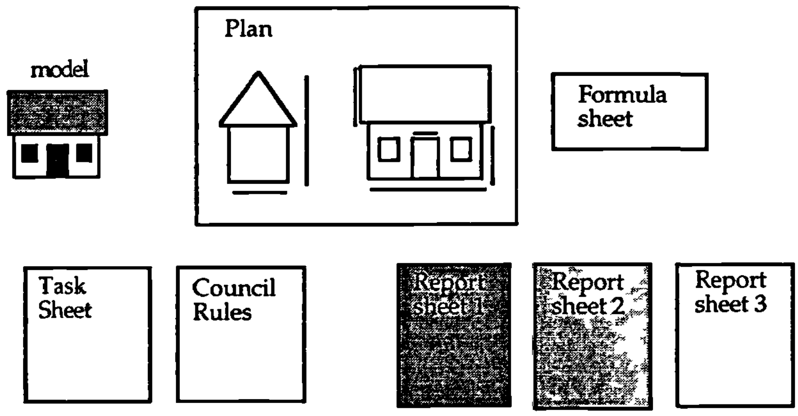
b1) activity overview

In the summer of their year 9 approximately half of the students in the top four sets at Amber Hill (n = 53) and four of the mixed ability groups at Phoenix Park (n = 51) were given the architectural activity (see appendix 11) in which they were asked to consider a model and a plan of a proposed house and decide whether the house passed certain Local Authority design rules. In order to do this students were given a scale plan of the proposed house, which showed different cross sections of the house, and a 3-D scale model of the same house. Because the students at Amber Hill were taken from the top half of the school's ability range and the students at Phoenix Park were not, there was a disparity in the attainment levels of the samples of students. The students from Amber Hill were taken from a significantly higher ability range, measured on their mathematics NFER tests, as shown in appendix 12. However my main aim was not to compare the overall performance of the students in the two schools, but to compare each individual's performance on the applied activity with their performance on a short written test. Approximately two weeks prior to the architectural task the students took a pencil and paper test which assessed all of the mathematical content they needed to use in the activity. This is given in appendix 13 and the results for this test are given in appendix 20.

Groups of approximately 12 or 13 students from each of four classes at each school were chosen by their class teachers to work on the architectural activity. Teachers at Amber Hill were asked to select students who were average for the group. At Phoenix Park there was a school trip on the day I was in school which meant that all of the students who did not go on the trip undertook the activity. The students worked on the activity in a non-mathematics classroom. When they arrived in the room I told the students that I was a researcher at London University and I was interested in the way that they approached an architectural problem. I asked the students if they knew what an architect did and we then discussed this for a few minutes. Students were also told that there were many different ways to solve the problem and they were not expected to follow any particular method. Students were asked to work alone. I then explained the activity in more detail.

Students were told that they had been given a plan of a house that somebody wished to build as well as a model of the house. They were told that the model and the plan were built and drawn exactly to scale and the two scales were given. Students were also given an extract from a council report about the design of houses. Students needed to look at the council report and decide which sections related to house design, they then needed to work out whether the proposed house passed the council's rules. Students were told that any formulae they needed had been given on a formula sheet and all of the pieces of information that they may need to solve the problem were somewhere in their pack. Students were given a small scale model of a house (approximately 4 x 3 x 2 cm), an A3 scale plan of the same house, a formula sheet, a task sheet and an extract from a council booklet on housing design. These are shown in figure 7.1 and, apart from the model, given in appendix 11. The students' task was to write a short report on paper provided, stating whether or not the proposed house passed the council's design rules. Students were also asked to say why they thought the council might have such rules and whether the rules were a good idea or not. For the main part of the activity students could solve the problem using either the model house or the scale plan, whichever they preferred.

Figure 7.1: The Architectural Activity



One of the main aims of the activity was to provide a demand which was related to the interdependence of the different aspects of mathematics within the activity, rather than the level of mathematical content. The mathematics that the students needed to use in the activity (multiplication, division, area, volume, percentages, angles, measurement) had been encountered by all of the students in all classes. Students had access to calculators at all stage of the activity.

The architectural activity comprised three main sections. The first section concerned a council rule that said that the volume of the roof of a house must not take up more than 70% of the volume of the main body of the house. To determine whether the house passed this rule the students needed to measure the model house, or take measurements from the plan of the house, find the volume of the roof and the house and find the proportion of the roof to the house. The second council rule stated that roofs must not have an angle at the top of less than 70°. The students therefore had to estimate the angle at the top of the roof, which was actually 45°, from either the plan or the model. This was a shorter and potentially easier task. The third requirement was to work out the size that the house windows, shown on the model, should be on the scale plan. This aspect of the activity was designed as an extension for students who finished the first two sections, but as very few students completed this section the results will not be given or analysed here.

Descriptions of the grades for the two tasks are given in appendix 21. All students attempted the tasks. In the tests the students were required to calculate the volume of a prism and a cuboid, find measurements, use scale and calculate a percentage. There were no significant differences between the results for the two sets of students on these tests (see appendix 20).

b2) Results

b2.1) roof volume

Table 7.9 shows the results of the roof volume activity for the students in each class, 1 was the highest grade possible, 4 the lowest. Table 7.10 shows a summary of these results with all of the classes in each school and grades 1 & 2 and 3 & 4 combined. Table 7.11 shows a cross tabulation of the roof volume activity and the appropriate tests. In table 7.11 a grade 1 for the tests indicates that students answered all of the relevant questions correctly, whereas a grade 2 indicates that they could not do one or more of these questions.

Table 7.9: Architectural volume activity results (n)

Amber Hill

set	grade: 1	2	3	4	n
1	3	2	9	0	14
2	0	2	8	1	11
3	6	7	1	0	14
4	6	3	4	1	14
	15	14	22	2	53

Phoenix Park

group	grade: 1	2	3	4	n
a	1	7	1	4	13
b	5	7	1	0	13
c	3	7	1	1	12
d	5	3	4	1	13
	14	24	7	6	51

Table 7.10: Summary of architectural volume activity results (n)

	1/2	3/4	
AH	29	24	53
PP	38	13	51

$\chi^2 = 4.44$, d.f. = 1, $p < 0.05$

Table 7.11: Cross tabulation of volume activity and test question results (n)

Amber Hill activity grade

test qu's	1/2	3/4	
1	23	15	38
2	6	9	15
	29	24	53

Phoenix Park activity grade

test qu's	1/2	3/4	
1	23	8	31
2	15	5	20
	38	13	51

These results reveal a number of interesting patterns. First of all, table 7.9 shows that the least successful students at the two schools were those in sets 1 and 2 (the highest groups) at Amber Hill. In sets 3 and 4 at Amber Hill and all four of the mixed ability groups at Phoenix Park, the performance of students was comparable. The failure of most of the students in sets 1 and 2 at Amber Hill to even partially solve the problem contributed towards the overall difference between the students at the two schools shown in table 7.10, in which 38 or 75% of Phoenix Park students solved some of the problem, compared with only 29 or 55% of the Amber Hill students, which was a statistically significant difference. This was despite the fact that the students at Amber Hill were of a significantly higher 'ability'. An analysis of the test results in the two schools shows that the students at Amber Hill did not fail to solve the activity problem because they were unfamiliar with the mathematical content. Indeed the students in sets 1 and 2 at

Amber Hill were the most successful on the tests, with 11 of the 14 set 1 students answering all of the test questions correctly. The students in sets 1 and 2 had learned the necessary mathematical knowledge, but they were unable to make use of it in a fairly open and demanding situation.

The results of the students on the activity contrast with the way that the students responded to the activity at the time of taking it. At Amber Hill the students all appeared to cope well with the task, they sat and worked quietly throughout the lessons, they did not ask for help, they reported enjoying the work and many of them wanted to stay into break to talk to me about the work. At Phoenix Park many of the students were noisy and disruptive, they wandered around during the activity, they talked about non-work issues and they appeared to do less work. The work completed by the students was therefore somewhat surprising, particularly in the case of the set 1 and 2 students at Amber Hill who only managed to make and write down some measurements during the one-hour lesson, despite their appearance of hard work.

Consideration of table 7.11, which shows the test and the activity results, reveals another interesting phenomenon. This shows that at Amber Hill 15 of the students (28%) could not calculate a volume in the activity, despite getting all of the test questions correct, compared with 8 (16%) Phoenix Park students. At Phoenix Park 15 (29%) of the students attained a grade 1 or 2 on the activity, despite getting the relevant test questions wrong, compared with 6 (11%) of the Amber Hill students. Thus a comparison of test and activity grades shows the tendency of some students at Amber Hill to learn mathematical methods that they were unable to make use of in a more realistic activity and the tendency of some Phoenix Park students to respond negatively to tests but use mathematical ideas to solve more realistic problems. Of the students in both schools who demonstrated awareness of the appropriate mathematical techniques in the test, 61% of Amber Hill students and 74% of Phoenix Park students made use of these methods in the applied activity

b2.2) roof angle

Table 7.12 shows the results of the students in each class for the angle activity and table 7.13 shows a summary of these results. Table 7.14 shows a cross tabulation of the results for the students of the applied angle problem against the relevant test question. In the test the students were given a 45° angle and asked whether it was 20, 45, 90 or 120 degrees. In the activity the students needed to locate the appropriate angle at the top of the roof and say whether it was more or less than 70°, the angle was actually 45°.

Table 7.12: Architectural angle activity results (n)

Amber Hill

	grade:	✓	x	n
set:	1	4	10	14
	2	4	7	11
	3	13	1	14
	4	13	1	14
		34	19	53

Phoenix Park

	grade:	✓	x	n
group:	a	12	1	13
	b	9	4	13
	c	11	1	12
	d	10	3	13
		42	9	51

Table 7.13: Summary of architectural angle activity results (n)

	✓	x	
AH	34	19	53
PP	42	9	51

$\chi^2 = 4.38$, d.f. = 1, $p < 0.05$

Table 7.14: Cross tabulation of angle problem and test question results (n)

Amber Hill

activity grade

		✓	x	
test qu's	✓	31	19	50
	x	3	0	3
		34	19	53

Phoenix Park

activity grade

		✓	x	
test qu's	✓	40	8	48
	x	2	1	3
		42	9	51

Ninety four per cent of Amber Hill students estimated the angle given in the test correctly, but only 62% of these students estimated the angle correctly in the applied activity. At Phoenix Park, 94% of students estimated the angle correctly in the test and 83% of these students estimated the angle correctly within the applied activity. Table 7.12 shows that the least successful students at Amber Hill were again in sets 1 and 2, the highest groups. In both of these groups this failure emanated from an inappropriate choice of method. For e ample, in the angle problem, the ten students in set 1 who said that the angle at the top of the roof (45°) was greater than 70°, all attempted to use trigonometry in order to determine the size of the angle, but they failed to use the methods correctly. Successful students estimated the angle using their knowledge of the size of 90° angles. Unfortunately, the sight of the word 'angle' seemed to prompt many of the Amber Hill, set 1 students to think that trigonometry was required, even though this was clearly inappropriate in the context of the activity. The students seemed to take the word 'angle' as a cue to the method that they were meant to use. The Phoenix Park students again showed greater success on the activity with 42 or 82% of students solving the problem, compared with 34 or 64% of Amber Hill students, which was a significant difference.

b2.3) council rules

In an analysis of the reasons the students offered for the different council rules there were no significant differences between the two schools. At Amber Hill the mean number of reasons given per student was 1.17, compared with 1.43 at Phoenix Park. The reasons that the students suggested appeared to be equally appropriate at the two schools, these mainly focused upon appearance, the environment, safety and the weather. This gives some indication that the students at the two schools had a comparable understanding of the context of the problem, despite the fact that some students failed to make use of their mathematical knowledge within the problem.

There were no significant differences in the performance of girls and boys on any of the architectural problems or related tests.

b3) Discussion

The students undertook the architectural activity and associated tests at the end of year 9, one year after the start of their different approaches. At this stage the difference between the mathematical behaviours of the two sets of students appeared to be emerging. This was particularly evident amongst students in sets 1 and 2 at Amber Hill. In set 1 for example, ten of the fourteen students could not solve the angle problem and nine of the fourteen students could not solve the volume problem within the context of the applied activity. At Phoenix Park the students were slightly less successful on the test questions, which could possibly be accounted for by the fact the students were taken from a significantly lower ability range, but the students were markedly more successful in the activities. The main problem that seemed to be experienced by the Amber Hill students related to an inability to decide what to do when they were not given explicit instructions. The students had learned appropriate mathematical methods, but when they were left to choose the methods to use they became confused. The students in set 1 for example appeared to use trigonometry, rather than estimation, because the activity was about angles and they related angles to trigonometry. They were not able to see the inappropriateness of trigonometry within the situation. Although it is not possible to draw firm conclusions about the reasons for the underachievement of students in this activity from the results of the activity alone, these results conform to other forms of evidence collected within the research study. The combination of these suggest that the students in sets 1 and 2 may have been less able to think holistically about the demands of the applied situation because they had been introduced to more rules and algorithms than other students, at a faster pace than other students. This may have disabled the students in a situation which required mathematical thought.

c) Planning a flat

c1) activity overview

One year later, at the end of year 10 all of the students in the top four sets at Amber Hill (n = 99) and all of the students in four mixed ability classes at Phoenix Park (n = 89) were given a second applied activity and set of related tests. *Planning a Flat* was adapted from a GAIM activity of the same name (GAIM, 1988). Students worked on the activity and accompanying questions (see appendix 14) over the period of two consecutive lessons, each lesson lasting one hour. The activity and questions were given to complete classes. The students at Amber Hill were, again, of a significantly higher ability than the students at Phoenix Park, measured on NFER tests (see appendix 15).

In the first lesson students were given an A3 plan of an empty basement flat. The plan showed only the structural features of the flat - the external walls, windows, chimney breasts and the front door. The students were asked to decide upon the intended owners of the flat, for example a couple, a family of three, a student and then decide upon appropriate rooms to put into the flat. Students then needed to draw rooms, doors and furniture onto the A3 plan, using their knowledge of measurement and scale. On the A3 plan of the flat students were given two important pieces of information. First, the scale of the flat was provided twice, in two different forms. A two centimetre line showed the size of a metre at the bottom of the flat plan and a box of information also gave the scale as 1:50 at the side of the plan. The second important piece of information concerned building regulations. A box at the bottom of the plan gave two regulations:

- Each "habitable" room (i.e. living room, bedroom) must have a window in it
- There must be two doors between a toilet and a kitchen.

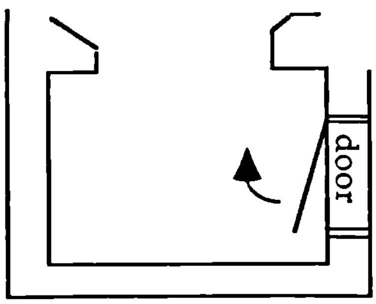
I pointed these regulations out to students and explained what they meant at the start of the lesson, I then stayed with the classes while they worked on their designs and questions. I started the first lesson by saying that I was interested in the way that students used mathematics in types of activity that they may meet when they leave school. I then told students that they would be spending one lesson designing and planning a flat and that they were to choose who the flat was for and the sorts of rooms they would provide. I explained about the building regulations and showed students the windows on the plan. Students were also provided with a blank piece of paper and told that they should use this to write who their flat was for and, at the end of the lesson, the advantages and disadvantages of their designs. I also explained to students that time was quite tight and that they must finish their flat design by the end of the lesson. Students were allowed to work together on the design of their flats if they wanted to, but they had to produce one design each.

In the second lesson students were given three questions to answer, which related to their flats. The first question appeared in the students' instructions as follows:

Carpet costs about £7.99 per square metre.
a) *Roughly* how much would it cost to carpet all of the flat?
Show all your working out.

The second question asked the students to say how much they would borrow from a bank if they needed the money to pay for the carpet, they were also asked to explain their decision. The final question that the students were given is reproduced below:

Street doors must open to an angle of at least 115°. Will the street door of the flat pass this regulation? (The door is shown on the diagram below)



(The actual drawing given to students was reproduced from their own flat outlines)

You <u>must not</u> use an angle indicator - explain how you have worked out your answer.

Approximately one month before taking the activity and related questions the students were given a short written test (see appendix 16) that assessed all of the mathematics which featured in the activity and related questions. The criteria for marking the activities and questions are given in appendix 22.

c2) Results

c2.1) tests

In the short written test the students from Amber Hill attained significantly higher grades on questions assessing area, angle and percentage, there were no significant differences on the question assessing scale (see appendix 23). These differences were mainly because of the high success rate of the set 1 students at Amber Hill, when these students were taken out of the sample the only significant difference between the two schools occurred in the question on area. The enhanced performance of the Amber Hill students on the tests would probably be expected given that the Amber Hill students were taken from the top half of the school's ability range.

c2.2) flat design

The students' flat designs were assessed using the GAIM (1988) criteria for the activity. These are given in appendix 22. Grade 1 is the highest grade, grade 5 the lowest. These produced the following results:

Table 7.15: Flat design results (n)

n	1	2	3	4	5	n
AH	31	24	7	18	19	99
PP	54	5	7	12	11	89

$\chi^2 = 17.46$, d.f. = 3, $p < 0.001$ performed on collapsed table with categories 1 & 2 combined

Table 7.16: Flat design results (%)

%	1	2	3	4	5	n
AH	31	24	7	18	19	99
PP	61	6	8	13	12	89

These results show that there were significant differences between the performance of the students at the two schools, with students at Phoenix Park gaining significantly higher grades ($p < 0.001$), despite the fact that the students were taken from a significantly lower ability range. The main difference between the two schools was that 61% of Phoenix Park students produced well planned designs, with appropriately sized and scaled rooms and furniture, compared with only 31% of Amber Hill students. Twenty-four per cent of the Amber Hill students drew rooms which were of an inappropriate size, or that contained wrongly scaled furniture and doors, this compared with 6% of the Phoenix Park students. This was despite the fact that 90% of Amber Hill students successfully used scale in the short, written test.

Another major difference between the two schools was described in chapter 6. This related to the types of rooms the students designed. Thirty-three per cent of the Phoenix Park students included unusual rooms such as disco rooms and bowling alleys in their flats, compared to approximately 3% of Amber Hill students. In general, the inclusion of these more unusual rooms at Phoenix Park did not mean that the students produced unrealistic designs with inappropriately sized rooms. Many of the designs were very ingenious entailing a creative use of space with interlocking rooms that saved on redundant hall or corridor space. In effect the students often gave themselves a more demanding cognitive task, but managed to attend to the rules that they were given and the constraints of size and scale to produce impressive designs. This reflected a general difference between the two schools that was marked. Many of the Amber Hill designs, with some exceptions, were inaccurate, sketchy and basic, despite the obvious commitment and enthusiasm shown by the students during the activity. Many of the Phoenix Park designs were of a much higher standard, and they included designs and furnishings that were carefully and accurately constructed. Students at both schools reported enjoying the activity immensely, particularly the Amber Hill students, many of whom asked if they could do more work of a similar nature.

The difference in the overall standard of the designs at the two schools may be partly explained by the fact that the Phoenix Park students were used to doing open-ended work. However, the demands of the activity were not particularly open, because the students were given explicit instructions about their task and they were carefully informed about the constraints they had to work with. The students at Phoenix Park had never encountered a similar design task in mathematics before, but they were used to doing other spatial activities and this experience probably helped them.

The students' inclusion of more creative and unusual rooms at Phoenix Park may also provide a clue to the overall difference in the performance of the students. The Phoenix Park students generally seemed to demonstrate a freedom of approach in the way that they worked with their designs. The students were given the opportunity to design a flat of any description, which meant that many of the students included rooms that they would have liked in their homes. They were not constrained by any perceived limits and they did not try to produce designs that a teacher would regard as appropriate. The students took an open approach to the task and this may have generally encouraged better designs. The fact that many students at Amber Hill believed mathematics was all about rule following and doing what was expected of them may have generally disabled students when they were given the freedom to produce their own designs. The students were certainly capable of performing calculations with scale and size, but they did not demonstrate this capability when they needed to. They, apparently could not (or would not) make use of their knowledge of scale, measurement and size that they demonstrated in textbook questions, within a more authentic activity.

c2.3) flat commentary

At the end of the first lesson the students were asked to consider their designs and state any advantages or disadvantages they could see. These were assessed using criteria given in appendix 22.

Table 7.17: Flat design notes results (n)

n	1	2	3	4	n
AH	11	19	36	33	99
PP	15	26	20	28	89

$\chi^2 = 6.17$, d.f. = 3, $p < 0.20$

Table 7.18: Flat design notes results (%)

%	1	2	3	4	n
AH	11	19	36	33	99
PP	17	29	22	31	89

These results show that approximately 32% of students in both schools did not write any notes (grade 4). This was because they were still finishing their flat designs. The rest of the students made some attempt at judging the suitability of their designs and higher percentages of Phoenix Park students gave advantages and disadvantages or used some thought in their descriptions, but there were no significant differences between the two schools.

c2.4) area question

In the second lesson the students were asked to answer three questions which related to their flat designs. The first question asked the students how much it would cost to carpet all of their flats, using carpet of a given price. The criteria for the assessment of this question are given in appendix 22.

Table 7.19: Area question results (n)

n	1	2	3	4	5	6	7	n
AH	33	30	9	2	8	6	0	88
PP	51	12	1	1	0	4	3	72

$\chi^2 = 17.68$, d.f. = 2, $p < 0\ 001$, performed on collapsed table with categories 3-7 combined

Table 7.20: Area question results (%)

%	1	2	3	4	5	6	7	n
AH	38	34	10	2	9	7	0	88
PP	71	17	1	1	0	6	4	72

In the question on area there were significant differences between the two schools with 71% of Phoenix Park students attaining the highest grade compared with 38% of Amber Hill students. Grade 1 was given for answers that gave a correct *approximation* of the cost of carpet, which was the requirement of the question. Grade 2 was given if the students calculated the exact area of the floor space of the flat, subtracting the space taken up by chimney breasts and other protrusions. Thirty-four per cent of Amber Hill students attained this grade. The decision to work with this degree of accuracy was not sensible in the context of the activity because carpet would need to be bought for the area including the chimney breast spaces. If these spaces were subtracted from the length of carpet bought there would not be sufficient carpet for the flat. Quite apart from this constraint, the question asked the students to work out roughly how much the carpet would cost and the word 'roughly' was highlighted.

A break down of the students' answers by group shows that a high proportion of students giving exact answers at Amber Hill were students from set 1. Indeed, this question showed the only unusual group effect, other questions were generally answered well by students in high sets at Amber Hill. Table 7.21 shows that 19 of the 31 students who gave an exact answer were in set 1.

Table 7.21: Area question results by group at Amber Hill (n)

grades:

AH	1	2	3	4	5	n
sets: 1	5	19	0	0	5	29
2	11	4	5	0	1	21
3	11	3	3	2	3	22
4	6	5	3	0	5	19

Table 7.22: Area question results by group at Phoenix Park (n)

PP (grades:)	1	2	3	4	5	n
groups: a	15	0	1	0	3	19
b	13	0	0	0	1	14
c	11	8	0	0	2	21
d	12	4	0	1	0	17

This response of the Amber Hill students was interesting because it demonstrated again, the influence of certain goals or constraints upon the way in which students responded to the question. The students who used an exact measurement of floor space to answer the question did not show a good understanding of the demands of the context, even though they had worked on their designs for the entire previous lesson. This was probably because they were doing what they thought was expected of them, which meant working with the numbers and ignoring the situation or context they were placed within. A week after the activities and questions were completed I interviewed the set 1 students and asked them their motivation for working out exact answers. A few of the students said that they had calculated exact answers because they had considered the 'real world' situation and decided that they needed that degree of accuracy in order to buy the correct amount of carpet, for example:

S: Because it has to be that exact, otherwise you would waste money, buying carpet that you don't need. (Sally, Amber Hill, year 10, set 1)

However, the majority of students indicated that they used an inappropriate degree of accuracy because they were in a mathematics lesson, for example:

B: In real life I would measure all the little bits - no I wouldn't, I'd just work it out roughly from the big square.
JB: So why didn't you do that here, wouldn't it have been easier?
B: 'Cause you're taught to apply all different skills in maths, I could have worked out the square but you're meant to use all different maths things. (Brian, Amber Hill, year 10, set 1)

C: In real life I would just take the length and width and have spare bits.
JB: You wouldn't subtract these bits?
C: No.
JB: So why didn't you do that here, it would have been easier.

C: Because I thought we had to do better than that, show what maths we can do and show the different styles of what we can do. (Chrissie, Amber Hill, year 10, set 1)

These students gave a clear indication of the way that their goals were formed in mathematics lessons, even in relation to a relatively open task. They did not consider the situation holistically and decide upon the best methods to use in the context of the activity, they tried to do the right thing for a mathematics lesson. It was this sort of thinking, 'showing what maths we can do' that probably caused the students at Amber Hill to try and use trigonometry, rather than estimate the angle, in the architectural problem. The students' responses also demonstrate the constraints that they felt that they had to work with, constraints that may have stopped the students from thinking mathematically. These constraints may also have disabled students when they were producing their flat designs. The students reported that they would have performed a different area calculation in the 'real world'. This may provide an important clue as to why individuals often use their own self-generated mathematics in real world situations and why they view the goals of mathematics lessons and real mathematical situations as different. This is an issue I shall return to in chapter 8.

Table 7.20 also shows that more of the Phoenix Park students were able to calculate an area, either using an approximation of the floor space or the exact floor space (grades 1 and 2). At Amber Hill 28% of students did not calculate any area correctly, despite the fact that 98% of students solved the area test question. At Phoenix Park only 12% of students did not calculate an area correctly, despite the fact that only 79% of them solved the area test question. This is also demonstrated by the following cross-tabulation tables which show large differences between the distribution of numbers between the two schools.

Table 7.23: Cross tabulation of area activity question and test question (n)

Amber Hill

		Activity 1/2	Activity 3-5
Test	✓	57	22
	x	7	3

Phoenix Park

		Activity 1/2	Activity 3-5
Test	✓	45	2
	x	18	6

Table 7.24: Cross tabulation of area activity question and test question (%)

Amber Hill

		Activity 1/2	Activity 3-5
Test	✓	64	25
	x	8	3

Phoenix Park

		Activity 1/2	Activity 3-5
Test	✓	63	3
	x	25	8

Table 7.23 shows that there were important differences between the two schools. At Amber Hill 25% of students correctly solved the area question in the test, but did not attain a grade 1 or 2 in the activity, compared with 3% of Phoenix Park students. At Phoenix Park 25% of students gained a grade 1 or 2 in the activity despite getting the relevant test question wrong, compared with 8% of Amber Hill students. In the test the students only needed to work out the area of a rectangle with given dimensions. In the activity the students had to measure the flat first as well as find its area. The flat was also more complex in shape than the rectangle given in the test. However, in the test there was only one way in which to solve the area problem which was to use the algorithm for area, in the activity many of the Phoenix Park students used other methods such as drawing squares onto their flat designs. Thus, some of the students showed that they were unable to use some basic mathematical facts within a test, but that they could show a flexibility of approach in solving a more authentic problem. The Amber Hill students showed that they could make use of their knowledge in a test but they had difficulty using the 'same' knowledge in an applied situation.

c2.5) bank loan question

This question asked the students to say how much they would borrow from a bank if they needed the money to pay for the carpet, they were also asked to explain their decision. The aim of this question was to assess the students' use of approximation and explanation. The vast majority of students in both schools gave a sensible approximation of the money they would need to borrow and there were no significant differences between the students on this question. The criteria for the bank loan question results are given in appendix 22.

Table 7.25: Bank loan question results (n)

n	1	2	3	4	5	n
AH	56	17	2	5	9	89
PP	51	12	2	3	3	71

$\chi^2 = 1.76$, d.f. = 2, $p < 0.50$, performed on collapsed table with categories 3-5 combined

Table 7.26: Bank loan question results (%)

%	1	2	3	4	5	n
AH	63	19	2	6	10	89
PP	72	17	3	4	4	71

c2.6) angle question

In the final question the students were asked to say whether the street door could open to an angle of at least 115°. The criteria for the assessment of this question are given in appendix 22. This question gave the following results:

Table 7.27: Angle question results (n)

n	1	2	3	4	n
AH	38	14	35	2	89
PP	53	7	7	4	71

$\chi^2 = 17.08$, d.f. = 2, $p < 0.001$, performed on collapsed table with categories 3 and 4 combined

Table 7.28: Angle question results (%)

%	1	2	3	4	n
AH	43	16	39	2	89
PP	75	10	10	6	71

These results show that the Amber Hill students were relatively unsuccessful at estimating an angle within the context of a problem, despite the fact that 96% of Amber Hill students successfully estimated a similar angle in a similar question on a test. Relatively high numbers of Amber Hill students attained grades 2 and 3 on the activity. Sixteen per cent of students gained a grade 2, which meant that they answered 'yes' without any explanation. This could mean that the students guessed the answer or they could not explain how they arrived at their answer. Thirty-nine per cent of Amber Hill students gave an inaccurate estimate of the angle, compared with 10% of Phoenix Park students. An analysis of the errors the students made in this category showed that most of the students gave one of three answers. Approximately one-third of those getting the answer wrong estimated that the angle was 90 + 2 plus 45 + 2 giving 112.5°. Approximately one-third of students gave answers that were not particularly informative such as 'the door will not open to 115°', the final third gave answers which could indicate that the real world variables caused them to give an inaccurate estimation, for example 'no it will not pass because the door will swing but then it will reach the stop' or 'there won't be enough room for it to be 115°'. These students probably did not estimate the angle with the accuracy that they used to estimate the angle given in the test.

The cross tabulation tables below show that a high proportion of Amber Hill students gained a correct answer on the test but did not gain a grade 1 or 2 on the activity. At Phoenix Park the students were more consistent with success on the test generally indicating success on the activity and vice-versa.

Table 7.29: Cross tabulation of angle activity question and test question (n)

Amber Hill

		Activity 1/2	Activity 3-5
Test	✔	50	34
	x	2	3

Phoenix Park

		Activity 1/2	Activity 3-5
Test	✔	52	8
	x	8	3

Table 7.30: Cross tabulation of angle activity question and test question (%)

Amber Hill

		Activity 1/2	Activity 3-5
Test	✔	56	39
	x	2	3

Phoenix Park

		Activity 1/2	Activity 3-5
Test	✔	74	11
	x	11	4

On the flat design activity and all of the related questions there were no significant differences between the performance of girls and boys at the two schools.

c3) discussion

The results of this applied activity reveal that there were significant differences between the performance of the students in the two schools in their flat designs, their use of area and their estimation of an angle. The lack of success amongst the Amber Hill students on various aspects of the activity was not caused by their lack of mathematical knowledge but appeared to derive from the goals the students formed in relation to the activity. In producing their flat designs the Amber Hill students did not seem to work with the freedom of the Phoenix Park students. The Phoenix Park students produced more unusual and creative designs which were also more accurate and appropriately sized and scaled. The Amber Hill students may have failed to make use of their knowledge of scale and measurement because they had not been told to demonstrate that piece of knowledge in the activity. The Amber Hill students indicated that they may have been more concerned to produce the 'right' sort of designs and appropriate rooms. In the question on area the students were able to work out the mathematical skills they should demonstrate and many of the students gave answers that were 'too' accurate for the situation or context because of their desire to 'show their maths'. These students demonstrated the influence of non mathematical goals upon their choice of mathematical procedure. If the students had been asked why they attempted to use trigonometry, rather than estimate the angle in the architectural problem they probably would have said the same thing - to show the skills that they had learned. A further 28% of Amber Hill students were unable to work out an area of any accuracy, compared with 12% of Phoenix Park students. In the question on angle many of the students again failed to show their mathematical knowledge of angle that they had shown in the test.

The performance of the Amber Hill students on various aspects of the flat design task suggests that they had difficulty making use of the mathematics they had learned in an applied situation. This did not appear to be due to a lack of mathematical knowledge, but the way in which the students interpreted the demands of the activity. This will be considered in more depth in the next chapter. At Phoenix Park the students performed well on all aspects of the task and related questions, despite the fact that the ability range of the students was lower than that of the students in Amber Hill.

7.2.3 Long term learning

a) Introduction

In this research students were assessed on a piece of their school work immediately before being taught the work, immediately after completing the work and then six months later. On each of the three assessment occasions the students took exactly the same test. The tests were designed to assess the learning that took place on a particular topic, in a similar style and format to the actual work. Because the Amber Hill students were taught in sets their work was usually targeted at very specific levels of content. This made the design of the assessment questions straightforward, I essentially designed questions which were replicas of the questions used in SMP textbooks, with different numbers and contexts. In Phoenix Park the design of the assessment questions was extremely difficult because the students were of different 'abilities', working at different levels of mathematics. However the lessons I assessed were more closed than was normal for the school which meant that the students were all working on the same area of mathematics.

This research deviated from other studies performed in the two schools because it involved a group of students in each school that were not in my case study cohort. In total the research involved one year 9 and one year 10 group from each of the two schools, both of the year 10 groups were taken from the case study cohort. This combination of different year groups meant that two classes taught by the same teacher, could be assessed in each school. In Amber Hill, the groups were a year 9 set 1 and a year 10 set 4, both taught by Edward Losely. In Phoenix Park the groups were both mixed ability, one in year 9, one in year 10, both taught by Rosie Thomas. Both teachers were in their second year of teaching and were popular with students. At both schools the head of department chose the two areas of work to be assessed, based upon time considerations.

b) Results

b1) Amber Hill

b1.1) year 9 set 1: Rates

This work involved a chapter on rates from SMP book Y2 chapter 4. The students were introduced to this work in the normal way, with the teacher explaining methods from the board and the students practising the methods in various exercises. The students worked on 'rates' for 9 lessons. The class was a set 1 group so the work was introduced at quite a fast pace, as is normal for the school. The assessment used questions which were similar in style and content to the textbook and gave a similar spread of difficulty (see appendix 17).

Twenty-two students were present on all three assessment occasions and each student was given 13 questions, giving a total of 286 assessment results for each of the three occasions. The three assessments gave the following results:

Table 7.31: Results of rates tests (n)

Pre-test - Post-test - Delayed post-test

	000	001	010	011	100	101	110	111
1a. 400 x 15	0	0	0	0	1	1	1	19
1b. 600 ÷ 14	0	0	1	1	0	1	3	16
2. 320 ÷ 80	0	0	0	2	0	0	3	17
3a. £15 - $22 £rate	0	0	8	4	1	1	5	3
3b. $rate	0	1	8	4	2	0	5	2
4. speed & times	15	0	6	0	1	0	0	0
5. 43.2/1 - 0.7 litres	3	4	5	4	0	1	1	4
6a. speed 11.15 - 12.39	6	0	14	2	0	0	0	0
6b. speed 12.39 - 13.48	6	0	15	1	0	0	0	0
6c. speed 13.48 - 16.03	18	2	1	1	0	0	0	0
7a.average increase	1	0	9	5	0	1	1	5
7b.average decrease	2	2	15	0	0	0	0	3
8. complex rate	10	1	4	1	2	1	1	2

Table 7.32: Summary of 3 rates tests

	n	%
000	61	21
001	10	3
010	86	30
011	25	9
100	7	2
101	6	2
110	20	7
111	71	25

Table 7.33: Successful Students

	could do work before the lessons	could not do work before lessons
success in post test	91	111
success in delay post test	77	35

Table 7.31 shows a clear pattern of results for different types of question. In the first three questions the students were given a simple rate e.g. 400 litres per minute and asked, for example, how many litres there would be in 15 minutes. The vast majority of students could solve these questions before the lessons on rates and in both post-tests following them (111). The next two questions on the test involved calculating the number of pounds per dollar and dollars per pound from the information £15 = $22. In response to this question most of the students fell into one of three groups. Eight students learned how to solve these problems, but could not solve them 6 months later (010), 5 students could solve these problems *before* their lessons on rates and immediately afterwards but had also forgotten six months later (110), only 4 students learned how to solve the problems during their lessons and remembered this work 6 months later (011). Most of the remaining questions were more representative of the difficulty of the work done in class. The majority of students could solve these questions immediately after learning about them in class, but had forgotten them 6 months later (010).

The results for the long-term learning tests were not positive. Table 7.32 shows that in 46% of the assessment occasions students either knew the work before they were taught it or did not learn it at any stage (111 and 000). In 30% of the occasions students learned the work but then forgot it (010) and in only 9% of the occasions students learned work and remembered it (011). Table 7.33 presents the results in a slightly different way. This separates the students who could do the work before the lessons from those who could not. This shows that the teaching of the work resulted in 111 (39%) successful assessment occasions immediately after the work, but only 35 (12%) 6 months later. This was despite the fact that the students worked on rates for 3 weeks of lessons and they were given assessment questions that were virtually exact replicas of the questions they worked on during their lessons.

b1.2) year 10 set 4: Mixing and Sharing

This work involved a chapter on ratio from SMP book B5 chapter 7, which students worked on, in the normal way during approximately 12 lessons. The assessment used questions which were similar in style and content to the textbook and gave a similar spread of difficulty (see appendix 17).

Eleven students were present on all three assessment occasions. These students were assessed on 9 questions, giving a total of 99 assessment opportunities for each of the three occasions

Table 7.34: Results of ratio tests (n)

	Pre-test - Post-test - Delayed post-test							
	000	001	010	011	100	101	110	111
1a. 1:5 [= 5 x 20]	0	0	0	6	0	0	1	4
1b. 1.5 [– 150 ÷ 5]	0	1	1	5	0	1	1	2
1c. 1:5 with 240 total	1	3	6	1	0	0	0	0
2a. 2:3 [7 ÷ 3 x 2]	5	0	6	0	0	0	0	0
2b. 2:3 [3 ÷ 2 x 3]	6	0	5	0	0	0	0	0
2c. give lower ratio	2	2	3	1	2	0	1	0
3. 360 into 5:7	0	0	0	2	0	1	1	7
4. 4,200 into 7:4:3	1	0	5	4	0	0	0	1
5. 100 into 1:3:2	6	0	5	0	0	0	0	0

Table 7.35: Summary of 3 ratio tests

	n	%
000	21	21
001	6	6
010	31	31
011	19	19
100	2	2
101	2	2
110	4	4
111	14	14

Table 7.36: Successful Students

	could do work before the lessons	could not do work before lessons
success in post test	18	50
success in delay post test	16	25

These results also show some clear patterns with different types of question. The first two questions on the test involved a straight-forward use of unitary ratios and most students could either answer these questions before they attended the lessons or they learned how to use them and could answer similar questions immediately after the lessons and six months later. The rest of the questions were slightly more demanding and required a greater understanding of ratios. These questions showed that the vast majority of students either did not learn how to use ratios at this level or they could use them immediately after their teaching but not six months later. In general the year 10 class were slightly more successful than the year 9 class as students learned work and could make use of it six months later on 19% of assessment occasions. However in over half of the assessment occasions students showed that they had learned work but then forgotten it or they did not learn it at any stage.

The results from Amber Hill, for year 9 and year 10 are, in some senses, surprising, because Edward, the teacher of the two classes, was extremely popular with students and students in a range of classes reported that he was the most effective teacher at the school. He had a good rapport with students and the students said that he helped them to understand work. The work was taught for three weeks and the assessments were almost identical to the textbook questions. However, in interviews the students in Edward's classes, like the students in other classes, reported that they could not remember work for very long after their lessons:

> JB: How long after you've done work in the textbook can you remember it?
> L: It depends - 10 minutes?
> M: All that time? It's as soon as I leave the lesson.
> JB: So you can't remember it, say 6 months afterwards?
> L: Oh no, oh my God no. (Lindsey and Marsha, Amber Hill, year 10, set 4)

This was a common view expressed by the Amber Hill students that was borne out by the results of these assessments.

b2) Phoenix Park

b2.1) year 9: Fractions

The year 9 piece of work was a short fraction investigation. This piece of work was very unusual for Phoenix Park because it was based upon the didactic teaching of algorithms and it was only taught for two lessons. When the head of department chose the activity he commented that it was the most 'didactic bit of teaching' they ever did at the school. The investigation involved finding and continuing patterns from long division and prior to introducing the activity Rosie taught all of the students how to perform long division without a calculator on the board. She started the work by showing students how to divide 1 by 9, she then showed them 2 divided by 9 and discussed some other examples with them. She then asked the students to try some other numbers and continue investigating patterns e.g. with ninths, sevenths, thirteenths. In this lesson, as is normal for the school, some students worked enthusiastically but about a third of the students did very little work. Most of the teaching for this lesson involved Rosie showing students how to do long division without a calculator on the board.

Fourteen of the students in the group were present for all three assessments of this work. In the assessment students were given a similar investigation to one they had worked on in class, based upon a SMILE card (see appendix 17). The assessment for this investigation combined exploratory sections when students had to think about patterns and explain them, with more algorithmic sections when students were asked to perform long division calculations, without a calculator.

The fourteen students were assessed on 16 questions, giving a total of 224 assessment opportunities for each of the three occasions. The results for each of the assessment questions are given below:

Table 7.37: Results of fraction investigation tests (n)

pre-test - post-test - delayed post-test

	000	001	010	011	100	101	110	111
1. describe a pattern	0	2	0	2	0	0	0	10
describe a pattern	7	6	0	0	0	0	0	1
2. continue pattern	0	1	1	2	0	1	1	8
3. explain pattern	1	3	1	8	0	0	0	1
4. continue pattern	3	1	1	3	1	1	2	2
continue pattern	5	2	1	3	1	0	1	1
continue pattern	5	1	1	2	1	1	1	2
continue pattern	6	3	0	1	1	1	1	1
5. 1 ÷ 7	5	0	8	1	0	0	0	0
2 ÷ 7	6	0	7	1	0	0	0	0
3 ÷ 7	6	0	7	1	0	0	0	0
describe pattern	6	0	7	1	0	0	0	0
describe pattern	11	1	1	1	0	0	0	0
6. 3 ÷ 7	5	0	6	3	0	0	0	0
4 ÷ 9	5	0	6	3	0	0	0	0
which is bigger?	2	2	6	3	0	0	0	1

Table 7.38: Summary of 3 fraction tests

	n	%
000	73	33
001	22	10
010	53	24
011	35	16
100	4	2
101	4	2
110	6	3
111	27	12

Table 7.39: Successful Students

	could do work before the lessons	could not do work before lessons
success in post test	33	88
success in delay post test	31	57

Table 7.38 shows that 33% of the work assessed in the test was not learned at any point (000), which may partly be a reflection upon my assessment which was designed to be pitched in the middle of the mixed ability group. Table 7.37 shows that most of the questions recording 000 were in the latter stages of the test, mainly involving division of numbers without a calculator. The most common response to the long division questions was 010, showing that students could remember and use the algorithm immediately after learning it but had forgotten it six months later. Of the eight students who used long division successfully in the post-test, four attempted to remember the same method in the delayed post-test, one successfully, the other four stated that they could not remember what to do. The rest of the students were not able to use long division at any stage. This may indicate that the work was too difficult for the group, or that students found it difficult remembering and making use of algorithms. Questions 1 to 8 of the test which did not involve long division gave a more varied pattern of performance, most of the students recording either 000, 111 or 011.

The students' overall response to the fraction investigation indicates that the work was not particularly effective, at least in terms of the mathematical content that was intended to be learned. However, table 7.39 shows that the results were not quite as bleak as those for the Amber Hill students. In 88 instances students learned work and remembered it in the post-test, in 57 instances students learned work and remembered it in the delayed post-test. This 88:57 ratio at Phoenix Park compared with ratios of 111:35 for the Amber Hill year 9 students and 50:25 for the Amber Hill year 10 students. It is unfortunate that this assessment happened to focus upon the school's most didactic piece of teaching and a short, focused investigation, rather than a longer project that the students would have worked on for a similar amount of time as the Amber Hill students studied their chapters. However, the results from the year 9 Phoenix Park students are interesting to contrast with the results of a more typical open approach to teaching adopted with the year 10 class.

b2.2) year 10: statistics

The year 10 piece of work was a statistical investigation. This involved students visiting different work stations around the room which had one line drawn on a piece of paper at each of them. At each of the stations students estimated the length of the line, without a ruler. Later visitors to the stations could see previous students' estimates. When the students had finished this activity they pooled the results and used them to learn about statistics. Some students looked into the different results for particular lines to see whether people's estimates improved as more students estimated, some looked at their own estimates as they went around the room to see if they improved as they went on, some compared accuracy of estimate with length of line. The students learned about absolute and relative error, some drew graphs of their results, some worked out cumulative frequencies, some learned how to use standard deviations. All of the students wrote reports explaining what they had found. The students worked on this activity for approximately 6 lessons.

In the assessment of this activity (see appendix 17) I gave the students some short questions on estimation and proportion and a longer question with some data which they could investigate using any statistical methods that they wanted. This was because different students learned about different statistical methods during the estimating lines activity. To assess the statistical investigation I gave each student a mark if they made effective use of a particular statistical method the first time, a mark if they successfully used the same or a more suitable method the next time and so on.

Fourteen students were present for all three assessments of the activity. The students were each given 8 questions, giving a total of 112 assessment opportunities for each of the three occasions. These questions gave the following results:

Table 7.40: Results of statistical investigation tests (n)

pre-test - post-test - delayed post-test

	000	001	010	011	100	101	110	111
1. estimate length	1	0	2	5	0	1	0	5
estimate length	1	0	1	6	0	0	1	5
estimate length	1	0	0	6	0	0	4	3
2. describe method	7	0	0	0	0	4	1	3
3. who is better?	6	0	1	5	0	2	0	0
idea is right	8	0	2	4	0	0	0	0
exact answer	11	0	2	1	0	0	0	0
4. use of statistics	0	0	0	13	0	0	0	1

Table 7.41 Summary of 3 statistics tests

	n	%
000	35	31
001	0	0
010	8	7
011	40	36
100	0	0
101	6	5
110	6	5
111	17	15

Table 7.42 Successful Students

	could do work before the lessons	could not do work before lessons
success in post test	23	48
success in delay post test	23	40

The results of this activity show a much greater degree of success, with the largest proportion of the results falling into the 011 category. Consideration of the first three questions on the test shows that the students used and continued to use estimates effectively as a result of their learning. However most students were unable to describe the method they had used either before or after the lesson when they were asked to do this. The questions on proportion show much less success, with most of the students recording 000 for these questions but, more encouragingly, most of the students who did learn how to calculate proportions could still do so 6 months later. The most effective part of the activity appeared to be the teaching of statistical methods and all but one student made good use of statistics both immediately after the activity and six months later.

The year 10 students' successful use of statistics 6 months after completing the activity contrasts with the year 9 students' unsuccessful use of long division 6 months after learning it. Neither group of students had been required to use either long division or statistics in the interim period so the success of the year 10 students was not due to continued use of statistics. It seems likely that the difference was due both to the nature of long division and statistics and the way that they were taught. In the statistical investigation the students needed to find out about statistics in order to gain important information from their data, they were taught to appreciate the usefulness of the methods they learned in showing them trends that they otherwise could not see. It is possible that the importance of the statistical techniques to the individual projects the students were pursuing, made the learning more effective and more meaningful for the students. There was a purpose to learning the different methods that the students could appreciate. In the long division lesson the year 9 students were taught how to divide numbers for the sake of finding an answer, although they later went on to look at patterns in their answers. The method they were shown for solving long division does not give much insight into why it works and it is difficult for students to gain a real understanding of long division. The fraction investigation was only worked on for two lessons, compared with the six lessons of statistics in Phoenix Park and the nine and twelve lessons of textbook work in Amber Hill. Despite this over half of the students learned the rules for long division and they could use them immediately after the activity but, perhaps not surprisingly, they had forgotten them 6 months later.

b3) comparison between schools

A chi-squared comparison of the results for the two schools, considering the numbers of students recording 000, 010, 011, 111 or any of the more unusual 110, 001, 100 or 101, gave the following results:

Table 7.43: Comparison of results year 9 (n)

Y9	AH	PP
000	61	73
110, 001, 100, 101	43	36
010	52	53
011	25	35
111	71	27
n	252	224

$\chi^2 = 21.55$, d.f. = 4, $p < 0.001$ [mainly due to high numbers of PP students recording 000 and 011 and low numbers recording 111]

Table 7.44: Comparison of results Y10 (n)

Y10	AH	PP
000	21	35
110, 001, 100, 101	14	13
010	31	8
011	19	40
111	14	16
n	99	112

$\chi^2 = 23.99$, d.f. = 4, $p < 0.001$ [mainly due to low numbers of PP students recording 010 and high numbers recording 011]

c) Discussion

Any comparisons between the two schools as part of this research exercise must be tentative because the assessment of the Amber Hill students was more valid than the assessment of the Phoenix Park students. This was because the Phoenix Park students were free to work in any way that they wanted and take their work in different directions. The questions given to the Phoenix Park students may not therefore have targeted the work they were doing. Because the classes at Phoenix Park were mixed ability the assessment also had to be pitched towards the middle of the groups. This meant that low and high attainers in the groups may not have been given the opportunity to show what they had learned. Neither of these problems existed in the case of the Amber Hill students who were given a fair assessment of the work they did during their lessons, set at the same level. However, it is noticeable that even though the Phoenix Park students may not have been given adequate opportunity to show what they had learned, they still remembered more of the mathematics assessed in their tests than the Amber Hill students. One clear result from Amber Hill was that the learning of many of the students, on both topics, was ineffective because the majority of students either did not learn the work they studied or they learned it but then forgot it again within a 6 month period.

7.2.4 Assessments of mathematical knowledge

a) Introduction

The superiority of the students' performance at Phoenix Park in applied mathematical situations is probably not surprising, given the students' greater experience of open-ended mathematical activities in lessons. The students at Amber Hill spent the vast majority of their time working through short, closed exercises assessing knowledge, rules and procedures that they had been taught by their teachers. Part of the reason that the school chose to teach in that way was to provide the students with a good preparation for examinations that assess mathematics in a similar format. This section will present the results of two different assessments which gave the Amber Hill students the opportunity to use the mathematics they had learned in a more familiar format. At the end of year 10 the two year groups of students took the same set of short contextualised questions that I had given them in year 9, plus two slightly more demanding questions. At the end of year 11 the majority of the cohorts in both schools took GCSE examinations.

b) Year 10 context questions

At the end of year 10 the students were given nine short questions set in different contexts. Two of the questions were additional to the seven given to the students in year 9 (see appendix 10). The new questions involved calculations of perimeter and area. All of these questions were set in contexts, except one of the fraction questions which was abstract. The results of these questions are given below:

Table 7 45 Y10 Chocolate splits

Grade	AH (n)	PP (n)	AH (%)	PP (%)
1	111	45	61	49
2	61	36	34	44
3	4	2	2	4
4	5	3	3	4

$\chi^2 = 1.94$, d.f. = 1, $p < 0.20$[1]

Table 7.46 Y10 Tug of war

Grade	AH (n)	PP (n)	AH (%)	PP (%)
1	104	42	57	52
2	71	38	39	42
3	2	3	1	2
4	5	3	3	4

$\chi^2 = 3.02$, d.f. = 3, $p < 0.50$[2]

[1]performed on collapsed table with categories 2 - 4 combined
[2]performed on collapsed table with categories 3 & 4 combined

Table 7.47 Y10 Cutting Wood

Grade	AH (n)	PP (n)	AH (%)	PP (%)
1	127	49	70	58
2	30	12	17	14
3	14	6	8	7
4	11	18	6	21

$\chi^2 = 13.75$, d.f. = 3, $p < 0.01$

Table 7.48 Y10 Fashion Workshop

Grade	AH (n)	PP (n)	AH (%)	PP (%)
1	115	34	63	40
2	41	18	23	21
3	10	8	5	9
4	16	25	9	29

$\chi^2 = 22.99$, d.f. = 3, $p < 0.001$

Table 7.49 Y10 Fences

Grade	AH (n)	PP (n)	AH (%)	PP (%)
1	21	5	12	6
2	2	3	1	4
3	11	20	6	23
4	95	39	52	45
5	53	19	29	22

$\chi^2 = 14.55$, d.f. = 3, $p < 0.01$[3]

Table 7.50 Y10 The Letter T

Grade	AH (n)	PP (n)	AH (%)	PP (%)
1	40	18	22	21
2	9	4	5	5
3	3	11	2	13
4	77	30	42	35
5	53	23	29	27

$\chi^2 = 7.77$, d.f. = 3, $p < 0.10$[4]

[3]performed on collapsed table with categories 2 & 3combined
[4]perf rmed on collapsed table with categories 2 & 3 combined

Table 7.51 Y10 Penalties

Grade	AH (n)	PP (n)	AH (%)	PP (%)
1	14	7	8	8
2	8	6	5	7
3	153	69	84	80
4	7	4	4	5

$\chi^2 = 0.82$, d.f. = 2, $p < 0.70$[5]

Table 7.52 Y10 Plants

Grade	AH (n)	PP (n)	AH (%)	PP (%)
1	10	7	6	8
2	4	5	2	6
3	159	67	87	78
4	9	7	5	8

$\chi^2 = 3.79$, d.f. = 2, $p < 0.20$[6]

[5]performed on collapsed table with categories 3 & 4 combined
[6]performed on collapsed table with categories 1 & 2 combined

Table 7.53 Y10 Fractions

Grade	AH (n)	PP (n)	AH (%)	PP (%)
1	18	9	10	11
2	27	6	15	7
3	112	51	62	59
4	25	20	14	23

$\chi^2 = 6.15$, d.f. = 3, $p < 0.20$

These results show that the performance of the students in the two schools was extremely similar. On the five questions assessing fractions and conservation of number there were no significant differences between the schools. On the two number group questions the Amber Hill students attained higher grades, mainly because a large proportion of Phoenix Park students did not answer these questions. There was no obvious reason why the students omitted these questions in particular, although the Phoenix Park students generally work on their projects for about three weeks and they were not used to working quickly through a set of questions. They may have omitted these questions because they were quite long. On the two questions involving perimeter and area the Phoenix Park students attained slightly higher grades. Appendix 24 shows the performance of students cross tabulated for each pair of questions assessing the same mathematics and the percentage of students who attained the same grade on each pair of questions. These results show that the students at the two schools responded to the different contexts in a very similar way.

The comparability of the performance of the students in the two schools is in some senses surprising given the difference in the experiences of the students in mathematics lessons. One reason that the Amber Hill students may not have out-performed the Phoenix Park students was that the questions were designed to assess understanding and most of them were not possible to answer by a simple rehearsal of a mathematical rule. The only question that would have allowed this was the abstract fraction question which simply asked whether $\frac{10}{14}$ or $\frac{16}{21}$ was bigger. Even this question showed no significant differences between the two sets of students with 10% of Amber Hill students and 11% of Phoenix Park students answering the question correctly.

c) Year 11 GCSE examinations

c1) results

At the end of year 11 Amber Hill entered 182 of the 217 students on roll for GCSE mathematics, this amounted to 84% of the students. At Phoenix Park 108 of the 115 students on roll were entered for the examination, which was 94% of the cohort. The two schools used different examination boards and tables 7.54 to 7.58 below give the results of the students at each school as well as the national results for the different examination boards:

Table 7.54: Amber Hill GCSE results

	A*	A	B	C	D	E	F	G	U	X	Y	n
entry (n)	0	1	4	20	25	40	37	26	19	10	0	182
% entry	0	0.5	2.2	10.9	13.7	22.0	20.3	14.3	10.4	5.5	0	182
% cohort	0	0.5	1.8	9.2	11.5	18.4	17 1	11.9	8.8	4.6	0	217

Table 7.55: National examination board results

	A*	A	B	C	D	E	F	G	U	total
%	3.2	8.3	16.9	27.2	13.3	14.2	10 5	4.4	2.0	100

Table 7.56: Phoenix Park GCSE results

	A*	A	B	C	D	E	F	G	U	X	Y	n
entry (n)	1	2	1	9	13	28	27	20	5	1	2	108
% entry	1	1.9	1	8.3	12	25.9	25	18.5	4.6	0.93	1.9	108
% cohort	0.9	1 7	0.9	7.8	11.3	24.3	23.5	17.4	4.3	0.87	1.7	115

Table 7.57: National examination board results

	A*	A	B	C	D	E	F	G	U	total
%	0.2	2.0	7.3	15.1	16.8	18.4	16.5	16.2	7.5	100

Table 7.58: Comparison of GCSE results (%)

	entry		cohort	
	AH	PP	AH	PP
A-C	13.7	12.0	11.5	11.3
A-G	84.1	93.5	70.5*	87.8*
% entered	84	94		

* χ^2 = 22.2, d.f. = 1, p < 0.001 (calculated using numbers not %'s)

These results show that similar proportions of students at the two schools attained A-C GCSE grades but significantly more Phoenix Park students attained A-G grades. Some of the factors that may have contributed towards the students' GCSE performances are considered below.

c2) Examination Preparation

The results given in chapter 3 show that approximately 75% of students from both schools were below the national average for the NFER examinations they took on entry to their schools. The students should not therefore be expected to attain GCSE grades that were comparable with average national results. However, the proportion of students attaining A- G grades at Amber Hill and A-C grades at both schools suggests that both sets of students were probably disadvantaged in some ways in the GCSE examination. Other forms of evidence indicate that the disadvantages the students faced were very different at the two schools. Before I consider the possible reasons for the differences in GCSE performance at the two schools I would like to consider the preparation that the two schools gave for the GCSE examination.

At Phoenix Park the teachers believed that they had neglected the examination needs of the students, because they had spent too much time teaching mathematics in the way that they believed it should be taught, without catering to the demands of the examination system. In year 11 I interviewed the students at both schools a few weeks after they had taken mock GCSE examinations. The students at Phoenix Park reported that they found aspects of this examination difficult. One of the difficulties they reported was meeting areas of mathematical content that they thought they had not encountered before.

> L: For our mocks I don't think we'd learned all the things that were in them. (Louise, PP, year 11, JC)

It was probably true that students had not encountered all of the mathematical procedures that were assessed in the examination, because during the majority of years 9, 10 and 11 the students would only have learned about new mathematical procedures if they had happened to need them during the course of a project. In the actual GCSE examination there was a question on the intermediate paper, of both boards, that asked students to solve two simultaneous equations. At Phoenix Park 42% of students did not attempt this question and the 11% who answered it correctly used a range of self-generated methods to do so. The procedure that is usually taught for solving simultaneous equations is relatively straight forward but the students at Phoenix Park had not been introduced to it and therefore could not use it. At Amber Hill 93% of students answered this question and 26% of students answered the question correctly.

The Phoenix Park students took their mock examinations at Christmas of year 11, prior to that time they had only ever worked on projects and it was not until the January of their GCSE year that the teachers started examination preparation with students. This included teaching new areas of content, such as factorisation, that the students had not encountered in their projects as well as revising the content that they had met before. Some of the students were not confident that the months between January and April provided enough time for them to cover everything they needed:

> S: There's a sudden rush of revision really. I feel perhaps we could have been taught some of the things much earlier on.
> P: Yes, perhaps start revision a bit earlier, I mean, I just, I suppose we'll know come May, but is there gonna be enough time to do it all? Perhaps there will be. (Simon & Philip, PP, year 11, JC)

The students also reported that their coursework projects were not easy to revise from:

> JB: How did you feel about the project work you'd done - could you use the maths you'd learned from that in the mock?
> P: Yes it definitely was in the exam, but I suppose the approach we took in doing it, it wasn't sort of like revision, I found it was very difficult to look through your coursework and revise from your coursework, because there was a lot of, not irrelevant things, but a lot of things that weren't actually covered in the exam. (Philip, PP, year 11, JC)

As well as the limited time the school gave to examination preparation, the students may also have been disadvantaged in the examination because Phoenix Park did not provide students with examination equipment such as calculators. This was true in the mock examination and the actual GCSE:

> L: Like the day before they told us all the equipment we needed and we had to go out and buy it and if you didn't have any money then you didn't have the equipment.
> H: Like it was your responsibility to take a calculator in and that.
> L: Yeah, like they usually supply them in lessons, then they didn't in the exam.
> (Helen & Linda, PP, year 11, MC)

The fact that the school did not lend the students calculators for the examination was fairly indicative of the school's relaxed approach to examinations in general. Martin said that they could not supply calculators because the mathematics department did not have the money to buy them: they had bought enough calculators at the start of the year, but they could not replace those that were lost or stolen. However, the lack of calculators undoubtedly disadvantaged some students in the examination. Six students wrote onto their actual GCSE papers 'I haven't got a calculator' and at frequent points in the examination they wrote out the method they had used in the questions, but did not evaluate the answers, thereby losing marks. In the questions that assessed calculator use the students correctly wrote out the keys they would press on a calculator, if they had had one, but they did not get any marks for the questions.

The relaxed atmosphere of the school also meant that many of the Phoenix Park students were not particularly 'geared up' for their GCSE examinations and many reported that they had not bothered with revision:

H: I can't say anyone I know is bothered about their GCSE's, I don't think we're revising or bottling down or anything, I think it hasn't hit us yet.

L: Yeah, I haven't done anything yet.

H: No, me neither.

L: Now I don't think I've got any time left to revise what's going to be in the exam and then you just leave it 'cause you don't know enough. (Helen & Linda, PP, year 11, MC)

Some of the students also reported that the lack of pressure exerted by teachers to get the students to work in lessons may have resulted in lower grades:

A: In most of the lessons the teacher just leaves you alone.

JB: Is that a good thing or a bad thing?

A: It can be bad, like when it's really near exams, like the mocks, I lost all my motivation about 3 weeks before, probably end up doing that in my GCSE's as well, lose all my motivation about 3 weeks before, I've lost most of it now. (Andy, PP, year 11, RT)

At Phoenix Park many of the students reported that the school's lack of attention to their examination needs disadvantaged them. The Amber Hill students' preparation for the examination was very different. The GCSE examination had a very high profile at Amber Hill and success in the examination was of primary importance to teachers and students alike. Indeed, the teachers at Amber Hill did not make any pretence of preparing students for more open, applied or real assessments of their knowledge. They were clear that their job was to prepare students for the GCSE examination in the best way possible. The students were also convinced of the aim of mathematics lessons and they reported that the high degree of motivation and hard work they demonstrated in lessons derived from their desire for GCSE success:

JB. So if you all dislike it so much, why do you work so hard in lessons?

C: Because we want to do well, maths GCSE is really important, everyone knows that. (Chris, Amber Hill, year 11, set 4)

The pressure the students received to do well at Amber Hill may have disadvantaged students in the examination in the same way as the lack of pressure to do well may have diminished the capabilities of the Phoenix Park students. However there were a number of indications that the Phoenix Park students faced a range of important and real disadvantages when they took their GCSE examinations, which the Amber Hill students did not have to contend with. Despite this, significantly more of the Phoenix Park students passed the GCSE examination than Amber Hill students. This suggests that the students at Phoenix Park attained higher grades than the students at Amber Hill, not because they had learned *more* mathematics, but because their understanding of mathematics was qualitatively different.

c3) procedural and conceptual questions

Further evidence for the idea that the two sets of students had developed a different kind of mathematical understanding is provided by an analysis of the different types of question that the students at each school answered correctly. During visits to the two examination boards I recorded the marks that each student attained for every question on the GCSE examination papers. I had previously divided all of the questions into the categories 'procedural' and 'conceptual'. Procedural questions were those questions that could be answered by a simplistic rehearsal of a rule, method or formula. They were questions that did not require a great deal of thought if the correct rule or method had been learned. An example of such a question would be 'calculate the mean of a set of numbers', if students had learned how to calculate a mean this question was straightforward, students did not have to decide upon a method to use, nor did they have to adapt the method to fit the demands of the particular situation. An example of a conceptual question was 'A shape is made up of 4 rectangles, it has an area of 220cm^2, write, in terms of x, the area of one of the rectangles' (diagram given). Such a question requires the use of some thought and rules or methods committed to memory in lessons would not be of great help in this type of question. My rule in allocating questions was therefore - if the question could be answered from memory alone it was procedural, if it also or, instead, required thought, it was conceptual. All of the examination papers, from both examination boards, included procedural and conceptual questions in approximate ratios of 2:1. An analysis of the procedural and conceptual questions that students answered correctly and incorrectly in each school reveals a significant difference between the schools. The following box and whisker plots show the distribution of the percentages of students attaining correct answers for the two different types of question at each school:

Figure 7.2: Percentages of students attaining correct answers for 'procedural' and 'conceptual' questions at Amber Hill

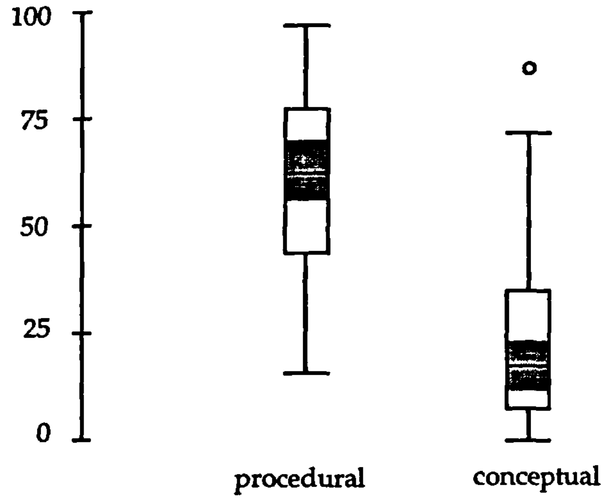
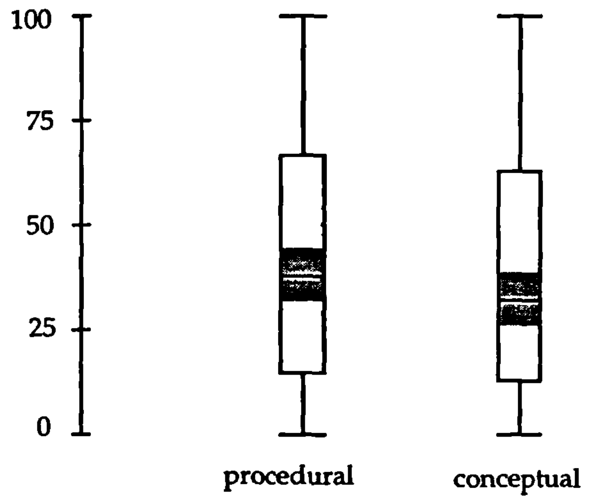


Figure 7.3: Percentages of students attaining correct answers for 'procedural' and 'conceptual' questions at Phoenix Park



The conceptual questions were often, by their nature, more difficult than the procedural questions, even for a student who had both learned and understood mathematical rules and procedures. The students at both schools would therefore be expected to answer more of the procedural questions correctly. At Amber Hill there was a marked difference between the percentages of students answering procedural and conceptual questions correctly, but at Phoenix Park the percentages of students correctly answering the conceptual questions was, on average, only slightly lower than the percentages solving the procedural questions. This result is further illuminated by a consideration of the different results for each examination paper.

In the following tables the average percentages of students correctly answering the different types of questions are given separately for each level of paper. At Amber Hill the students in sets 7 and 8 took a graduated assessment scheme with their own examinations, papers GA and GB, at foundation level; other foundation students took papers 2 and 3 (foundation level, n = 101). Intermediate students took papers 3 and 4 (n = 58) and higher level students took papers 4 and 5 (n = 23). At Phoenix Park the P papers were taken by foundation level students (n = 44), the Q papers by intermediate students (n = 48) and the R papers by higher level students (n = 16).

Table 7.59: Average percentage of students attaining correct answers for each paper at Amber Hill

Amber Hill	procedural	conceptual	pro + conc
GA	68	37	1.8
GB	45	21	2.1
2	60	51	1.2
3	53	40	1.3
4	47	25	1.9
5	47	24	2.0

Table 7.60: Average percentage of students attaining correct answers for each paper at Phoenix Park

Phoenix Park	procedural	conceptual	pro + conc
1P	44	28	1.6
2P	53	33	1.6
1Q	41	55	0.7
2Q	30	29	1.0
1R	50	39	1.3
2R	50	63	0.8

These results will now be considered alongside the general GCSE results for each school.

c4) discussion

Similar proportions of students at Amber Hill and Phoenix Park attained GCSE grades A-C. Consideration of the students' results on conceptual and procedural questions for the 'higher' examination level (papers 4 and 5 at Amber Hill, paper R at Phoenix Park) show that the students at the two schools demonstrated different patterns of performance at this level. The results show that the Amber Hill students correctly answered approximately 2 procedural questions to every 1 conceptual question and the Phoenix Park students attained approximately equal numbers of each question correct. The main source of disadvantage for the potential A-C grade students at Amber Hill seemed therefore to be the conceptual questions which took up approximately one-third of the examination paper. All of the students who took the higher paper at Amber Hill were in the top set and it seems likely that the speed at which they encountered work and the closed and rule bound nature of their experience would have inhibited their performance on these questions.

At Phoenix Park the students attained equal proportions of each question correct, even though many of the conceptual questions were quite demanding. This suggests that the students would have done much better at this level if they had been taught more of the procedures that were assessed in the examination. Some of the students who could have attained A-C grades also indicated that they were fazed by their lack of knowledge of formal procedures:

> L: There were loads we hadn't done weren't there? - there were all those ones with weird equations that we'd never seen. (Lindsey, PP, year 11, JC)

The main source of disadvantage for the potential A-C students at Phoenix Park seemed to be their lack of procedural knowledge, which was important because the procedural questions took up two-thirds of the examination paper. Despite this, the overall attainment of the two sets of students was broadly equivalent.

A consideration of the proportion of students attaining grades A-G at each school shows that the Phoenix Park students were significantly more successful. At Amber Hill only 84% of entrants and 71% of the cohort attained grades A-G, this compared with 94% of Phoenix Park entrants and 88% of their cohort. Indeed the A-G results for Phoenix Park were similar to national averages even though the cohort was considerably lower than average on entry to Phoenix Park. The distribution of grades in each school shows that this difference seemed to be due to the fact that more of the Phoenix Park students who were entered for the examination attained grades E, F and G (57% at Amber Hill, 69% at Phoenix Park), whereas more of the Amber Hill students failed the examination (16% at Amber Hill, 7% at Phoenix Park). This was despite the fact that Amber Hill did not enter 35 or 16% of their students and Phoenix Park entered all but 7 or 6% of their students. These results give clear evidence of a superior performance from the students at Phoenix

Park, particularly those students who were entered for the foundation level papers. This included students taking papers GA, GB, 2 and 3 at Amber Hill and paper P at Phoenix Park. An examination of the types of questions answered correctly across all of these papers shows that students at both schools answered approximately 1.6 procedural questions correctly to every 1 conceptual question. Thus the Phoenix Park students did not attain higher grades because they answered more of a particular type of question correctly, they attained higher grades because they answered more of both of these types of question correctly. One source of disadvantage for the Amber Hill students was probably the fact that the students who should have got grades E, F or G were in low sets, whereas the Phoenix Park students were in mixed ability groups. The students in the low sets at Amber Hill reported that they had become disaffected by their placement in these sets and they did not see any point in aiming for a 'low' GCSE grade:

> S: I'm not putting, I'm not saying 'cause we're in the lower set we're not expected to enjoy it ... it's just... you're looking at a grade E and then you put work in towards that ... you're gonna get an E and there's nothing you can do about it and you feel like...what's the point in trying, you know? what's the difference between an E and a U? (Simon, Amber Hill, year 11, set 7)

This disaffection which related to setting restrictions will be considered in more detail in chapter 10. The other probable source of disadvantage for the Amber Hill students was simply that they had developed a less effective mathematical understanding and this will be considered in more detail in the next chapter.

An interesting pattern that was demonstrated by the conceptual and procedural results shows that at Phoenix Park there was a steady increase in capability on conceptual questions as the papers became more difficult. This trend is perhaps consistent with the nature of mathematical confidence and ability, the more competent students, entered for the higher papers, were simply more willing and able to tackle questions with a conceptual demand. The same trend was evident at Amber Hill between the foundation and intermediate papers, but this stopped at the higher level. This, I believe, was due to the nature of the learning of the top set students and chapters 9 and 10 will further the idea that many of the top set students at Amber Hill were disadvantaged by their placement in this set and the fast and procedural nature of their mathematical experiences.

Appendix 25 shows two scattergraphs which show the students' NFER results taken on entry to the school set against their final GCSE scores. These graphs and their accompanying statistics show that there was a particularly low correlation between these two assessments at Amber Hill school, which is an issue I shall return to in chapter 10. In appendix 25 I have circled the Phoenix Park students who were the most badly behaved and apparently unmotivated students in the year group. This graph shows that these students did not underachieve, in relation to other students, on the GCSE examination. This could mean that the students engaged with their mathematics for at least some of the time and that their bad behaviour (and other students' good behaviour) was a less effective measure of their mathematical learning than would normally be assumed.

An overall consideration of the GCSE results indicates that if Amber Hill and Phoenix Park's approaches were to be evaluated in terms of examination success alone, the Phoenix Park approach would appear to be more successful. This is despite the fact that the Amber Hill approach was meant to be examination-oriented. This was particularly true for the students at the E-G end of the GCSE spectrum. However there were some indications that the Phoenix Park approach may also have advantaged the most able students in the school. At Phoenix Park school one student attained an A* and two students attained an A, from a cohort of 115 students. This is a higher proportion than the national average for the examination. At Amber Hill no students attained A* grades and one student attained an A, from a cohort of 217 students. This proportion was much lower than the national average for the examination. Observations of the students who attained grades A* and A in their mathematics lessons at Phoenix Park showed that they received quite exceptional mathematical experiences at the school. This was because all of the students were given mathematical starting points that they could extend in any way that they liked and the particularly able students would often extend their work in very interesting directions, using mathematical thought that was way in advance of the demand of a GCSE examination. They were motivated students so they received quite a lot of teacher attention and they would often spend time having advanced mathematical conversations with each other and with their teachers. The students really enjoyed mathematics and the mathematical investigations they pursued in class gave them access to a breadth and depth of understanding that I do not believe it would be possible to gain from working through textbook questions.

A consideration of the students' performance on procedural and conceptual questions on the GCSE examination also shows that the students at the two schools attained broadly similar grades, in different ways. The Amber Hill students were much more successful on the procedural questions, which suggests that their examination performance would be enhanced if they were able to think about and solve more of the conceptual questions. The development of this capability would probably also advantage students in many other situations, because the conceptual questions required a depth of thought that would be useful in a number of applied and 'real world' settings. The Phoenix Park students would probably achieve greater examination success if they learned more of the standard mathematical procedures that are assessed in the GCSE examination, but it seems unlikely that this would advantage the students in any other situation than a mathematics examination. This raises questions about the appropriateness of the mathematics assessed in the GCSE examination, which is an issue that I shall return to in the final chapter.

7.3 Discussion and Conclusion

I would like to suggest that the results of all of the assessments that have been reported in this chapter were broadly consistent. These all showed that the Phoenix Park students had developed a mathematical understanding that they were more able to make use of than the Amber Hill students. This was demonstrated in applied situations, long term assessments and conceptual GCSE questions. Even within more traditional assessments the Phoenix Park students performed as well, or better, than the students at Amber Hill. I believe that these results were all indications of the same phenomenon: the students at the two schools had developed a different *kind* of learning. The Phoenix Park students did not have a greater knowledge of mathematical facts, rules and procedures, but they were more able to make use of the knowledge they did have in different situations. The students at Phoenix Park showed that they were flexible and adaptable in their use of mathematics, probably because they understood enough about the methods they were using to utilise them in different situations. The students at Amber Hill had developed a broad knowledge of mathematical facts, rules and procedures that they demonstrated in their textbook questions, but they found it difficult remembering these methods over time and they did not know enough about the different methods to base decisions on when or how to use them or adapt them.

There were many indications that the Amber Hill students had developed a shallow knowledge of a wide range of procedures which they could use when assessments were explicit or straight-forward. The Phoenix Park students did not know as many efficient rules and methods but they were prepared to invent their own or adapt something they knew when they needed to. Further evidence of these important differences in the students' mathematical behaviour will be presented in the next chapter which will also relate the apparent differences in the students' knowledge and understanding to the approaches of the two schools.

Chapter 8 Different Forms of Learning

8.1 Introduction

The aim of this chapter is to consider the different assessments and indications of the students' mathematical understanding that have been presented so far, to provide an explanatory framework for the apparent differences between students at the two schools and to use this framework to inform some of the suggested positions in the field of situated cognition. In the first part of the chapter I will consider the nature and extent of the differences between the learning of the students at the two schools, illuminated by the students' reflections upon their GCSE experience, I will then present a case for two different forms of mathematical learning. One of these forms of learning, I will suggest, is inert (Whitehead, 1962), inflexible and tied to the situation or context in which it was learned. The other form of learning appears to be of a more adaptable, usable and relational (Lave, 1993) form.

8.2 The Differences

In the last chapter I presented the results of a number of different forms of assessment. These assessments, taken together, seem to indicate some important differences between the learning of the students at the two schools. I will now suggest that whilst the performance differences on these assessments were not always large, they in fact, reflected an important variation in the nature of the students' understanding.

8.2.1 Amber Hill

a) Performance patterns

There was evidence from both lesson observations and the assessments shown in the last chapter that the students at Amber Hill were able to use the mathematical knowledge they had learned when the requirements of questions were explicit. This meant that they could work through their exercises in class with relative ease, they performed well on all of the short, written tests that accompanied the applied activities and they were able to answer many of the procedural GCSE questions. The difficulties seemed to occur for the students when the requirements of questions were not explicit, when they needed to use some mathematics after a period of time, when they had to apply mathematics and when they needed to combine different forms of mathematics. I believe that these difficulties occurred because of a combination of the nature of the students' understanding of mathematics and the perceptions that the students had developed about mathematics.

At Amber Hill many of the mathematics lessons were rapidly paced, closed and procedural. This seemed to have had a clear impact upon the students, causing them to develop a shallow, procedural knowledge, and a perception that mathematics was all about learning and remembering rules and formulae. Neither the students' views nor the procedural nature of their learning were surprising given that the students only had time in lessons to try and learn methods; they did not have the time, nor did they receive the encouragement to think about them deeply. The combination of the students' ideas and understandings meant that they experienced difficulty in a number of different situations. The students themselves became aware and concerned about these difficulties when they took their mock GCSE examinations. Until that time, they had thought that they would be successful in mathematics if they learned all the rules and formulae they were introduced to in their lessons. In the mock GCSE examination the students found that this was not the case:

> A: It's stupid really 'cause when you're in the lesson, when you're doing work - even when it's hard - you get the odd one or two wrong, but most of them you get right and you think well when I go into the exam I'm gonna get most of them right, 'cause you get all your chapters right. But you don't. (Alan, AH, year 11, set 3)

The students encountered a variety of problems in the GCSE examination which were similar to the problems that were demonstrated in the various assessments reported in the last chapter. The first problem they experienced was simply remembering mathematics over a period of time. This was demonstrated by the long-term learning assessments and supported by the students' comments in interviews:

> D: Yeah it's maybe one chapter and then later on in the book another chapter but by that time you've forgotten it and you have to go back.
> JB: Between the two chapters?
> D: Yeah and you have to go back to the old chapter and do that again so you can remember it. (Danielle and Paula, Amber Hill, year 10 set 2)

S: Usually, like I know that pi is equal to 3.14 because it's easy to remember but I don't actually remember like the diameter, how to find out the diameter of a circle 'cause we done that a few weeks ago.
B: No I can't remember that, like the circumference and the radius.
S: I wouldn't know now how to think about it, like we done that what about 3 weeks ago? and I could do it when we finished it but I don't think I'd remember it now. (Sam & Bridget, Amber Hill, year 10, set 3)

Many of the Amber Hill students talked in similar terms about the difficulty they experienced using mathematics after a period of time. Sam's comment gives some indication of the reason for this, because she said that she 'wouldn't know now how to think about it', suggesting that because her memory of the procedure had gone she would not be able to think about the mathematics. This leads to the idea that students were disadvantaged in two related ways. First they experienced difficulties because of their belief that they had to rely upon their memory in order to solve mathematical problems.

S: Yeah you have to learn it so that you can tell the difference in the question as to which rules you use. (Sara, AH, year 11, set 3)

This belief stopped them from trying to think about mathematics and work things out:

L: In maths you have to remember, in other subjects you can think about it. (Lorna, AH, year 11, set 1)

The students were also disadvantaged, because the way in which they had learned methods had not given them access to a depth of understanding that helped them to remember methods. This meant that students had problems even when they were presented with straightforward mathematical questions that assessed isolated mathematical concepts in forms that were very familiar to them. For example, 93% of students who took the intermediate GCSE paper attempted to use the procedure they had learned to solve two simultaneous equations, but only 26% of students answered the question correctly. The rest of the students used a confused and jumbled version of the procedure.

A second problem was experienced by students when they needed to use different types of mathematics within the same activity. For example, in the first part of the roof problem in the architecture activity students needed to use measurement, scale, volume and percentage. The combination of these methods in the same problem seemed to cause difficulties for the students and the students reported similar difficulties in the GCSE examination:

> M: 'Cause in the exam, we only had about 2 of them questions from class, in the whole exam - probably the whole year got them right.
> JB: What sort of questions - when you say there were only 2 of them, what sort were they?
> M: Like, if you have this and that number and then, how do you do it?
> JB: So what was the rest of the exam if it wasn't that?
> M: It was jumbled up, it was like ratio and then it was like digits and then the next question was that then it went back to ratios again, then it went to bearings, then it went to that and that, you see? (Marco, AH, year 11, set 4)

In SMP lessons the students were used to learning one procedure and then practising it, in the examination they needed to think about and combine different procedures and flexibly switch between different procedures in different questions. For many of the students, this demand was too great.

A third and even bigger problem was created for the students in situations when they needed to apply the methods they had learned. This was clearly demonstrated by the two applied assessments reported in the last chapter. These showed that students successfully used knowledge in tests, but failed to make use of the 'same' knowledge in more applied activities. In class the students would generally stop and ask for help if they encountered an applied question or if they encountered a question that was slightly different to the question that had been used as an example. In the GCSE examination the students also reported that they were unable to apply the methods they had learned:

> L: Some bits I did recognise, but I didn't understand how to do them, I didn't know how to apply the methods properly. (Lola, AH, year 11, set 3)

Thus, even when students knew they had learned an appropriate piece of mathematical information, they could not do anything with it.

The difficulties the students experienced all seemed to relate to or fit within an overarching phenomenon which concerned the way in which students interpreted the demands of situations. This interpretation of experience seemed to be important, partly because it governed the way in which students responded to different situations and partly because it seemed to characterise the real difference between the learning of the students at the two schools.

b) Interpreting the demands of situations

In the architectural problem described in the last chapter, a number of the Amber Hill students did not calculate the volume or the angle of the roof correctly, this was not because they could not perform calculations with volume or angle, but because they needed to interpret the question in order to determine what to do. Many of the students were unsuccessful because they saw the word angle and thought that they should use trigonometry; it was their interpretation of the demands of the situation that failed them. There were other indications that the Amber Hill students were generally fazed by the two applied situations that they were given in year 9 and year 10, because these required them to interpret the activities and decide what to do. This confusion was similar to the confusion students experienced when they moved between different exercises in their textbooks. They could do the mathematics, but they could not work out what was needed.

In the examination this was also a major concern for students and they related many of their difficulties to the fact that the examination questions did not contain any cues in the way that their textbook questions did. In the textbook questions the students always knew what method to use - the one they had just been taught on the board, and if a question required something different or additional to this, there was always some clue in the question that would indicate what they had to do:

> G: It's different and like the way it's there like.. not the same .. it doesn't like tell you it, the story, the question, it's not the same as in the books ... the way the teacher works it out. (Gary, AH, year 11, set 3)

Although the students had generally worked hard in lessons and they had learned a wide range of mathematical methods and rules, they experienced diffculty in the examination because they found that the questions did not only require a precise and simplistic rehearsal of a rule, they required them to understand the questions and to know what the questions were asking them:

> A: We had one question, didn't we, and it's got like, what was it?, something stupid like ... it was symmetry, you know, lines of symmetry, we had to change it round and it was, oh, it just said like, I've forgotten what it said now, but it had like this sentence and you thought - what do I do? - it didn't explain what you had to do in the paper

and it was about 9 marks for that and you lost 9 marks just because it didn't tell you what to do. (Andy, AH, year 11, set 3)

G: Yeh in the exam it's like essays and that and .. questionnaires ..they're like misleading, and it's the same with graphs, they're misleading, graphs, and the questions, they're really misleading and if you can't understand one part you can't get the next part, and then you start panicking, but in the book and in the class it more or less explains itself. (Gary, AH, year 11, set 3)

In their textbook lessons the students had not experienced these demands, for the textbook questions always told them 'what to do', they always followed on from a demonstration of a principle, method or rule. Unfortunately the textbook questions never, at any point, required students to decide upon a method to use and, as Gary said, 'in the book and in the class it more or less explains itself'.

The students gave a clear picture of not knowing what to do in their examination, partly because they did not know the correct procedures to use. This problem can be related back to the students' belief that mathematics was a rule-bound, memory-based subject. The students could not think about and decide what was required of them in the examination because they believed that thinking was not what they were meant to be doing. They had been trained to learn rules and to spot clues in questions, rather than to interpret situations mathematically:

L: In maths you have to remember, in other subjects you can think about it, but in exams the questions don't really give you clues on how to do them. (Lorna, AH, year 11, set 1)

In this extract Lorna described quite clearly the problem she faced. She could not think about the requirements of the question, because 'in maths you have to remember', but how was she supposed to remember when the question did not contain any clues? Other students also described the difficulties they experienced when the clues or cues they were used to were absent:

G: You can get a trigger, when she says like simultaneous equations and graphs, graphically, when they say like ... and you know, it pushes that trigger, tells you what to do.
JB: What happens in the exam when you haven't got that?
G: You panic. (Gary, AH, year 11, set 3)

In the mock examination some of the teachers even gave students the cues they needed to answer the questions:

> L: My mind just went totally blank and I was really scared, a total blank, and I just couldn't focus, my concentration went completely and I just sat there like this... and I asked a question and said can you read it to me and explain a bit more and, without breaking the regulations she told me what it was about and I went, oh, yeah I remember now... and afterwards Miss Neville said to me you know that and - well sometimes you just need something to give you that little push, something to make you twig what it's about. (Liam, AH, year 11, set 3)

Liam's teacher told him after the examination that he 'knew that' because Liam knew how to operate the procedure, but he did not know which procedure to use or why. These students all related their inability to cope in examinations with the fact that their examinations did not give them 'triggers' or 'clues' that told them what to do. Every one of the students interviewed in year 11 was convinced of the same problem: they could not interpret the demands of the examination questions, they knew mathematical rules and procedures, but they could not make use of them. Some of the students described this as not being able to apply their mathematics, some talked about the absence of cues, others talked about not knowing the procedure to use. But they were all describing different aspects of the same problem, they could not use the methods they had learned unless the requirements of questions were explicit:

> 'Cause you haven't got a book (...) and so you've got to think of it and you think of it, but you think - but it could be, and then you think of about 20 different things it could b and you've got to decide which one. (Sara, AH, year 11, set 3)

The students' responses to the examination seemed to be consistent with the mathematical behaviour they demonstrated in the assessments reported in the last chapter.

c) Using mathematics in the 'real world'

I would like now to link the students' responses to the GCSE examination and their responses to the applied and long-term assessments to the way in which they used mathematics in non-school settings. When the students were in years 9 and 10, I asked all of the students I interviewed (n = 40) to think of situations when they used mathematics outside of school and to tell me whether they made use of school learned methods in these situations. They, like the adults observed in other research settings (Lave, Murtaugh & de la Rocha, 1984; Masingila, 1993; Nunes, Schliemann & Carraher, 1993), all said that they abandoned school mathematics and used their own methods:

> JB: And when you use maths in situations outside of school do you use the methods you have learned in school or do you tend to use your own?
> D: You use your own.
> S: Yeah you use your own. (Scott and Dean, Amber Hill, year 10, set 4)

> S: I use my own methods
> JB: Why?
> S: It's easier, 'cause I know how to do it myself then don't I? it makes more sense. (Sacha, Amber Hill, year 11, set 4)

> P: No, you use your own methods.
> D: Yeah, your own methods. (Danielle and Paula, Amber Hill, year 10, set 2)

Previous research on the way in which adults have used mathematics in different settings has demonstrated that adults were unable to use much of the mathematics they learned in school in 'real world' situations (Lave 1988). These students suggest that they could not use the methods that they had learned in school in 'real world' situations, even when they were still at school. This is probably not surprising given that students said that they could not remember the mathematics they had learned a few weeks after learning it, when they needed to use it in another chapter of their books, in the same social situation with similar mathematical demands. But the students did not only choose their own methods over their school-learned methods because they could not remember or use school learned mathematics. They chose not to use school learned methods because of the way they interpreted the demands of the 'real world'. When I asked the students whether they believed the demands of the classroom and the 'real world' presented any similarities, they all reported that the two situations were completely different:

JB: When you use maths outside of school, does it feel like when you do maths in school or does it feel....

K: No, it's different.

S: No way, it's totally different. (Keith and Simon, Amber Hill, year 11, set 7)

The students analysed these differences in interesting ways:

J: They seem more important, worth doing, the things you do outside of school.

JB: Why is that?

J: Because you are doing it for yourself. (John and Paul, Amber Hill, year 10, set 1)

G: I use my own methods.

S: Yeah.

JB: Why is that do you think?

G: 'Cause when we're out of school yeah, we think, when we're out of school it's social, you're not like in school, it tends to be social, so it would be like too much change to refer back to here. (George, Amber Hill, year 10, set 3)

R: It's different 'cause you're like you're doing it your own way and you're relying on yourself to get it right.

D: Yes I think it's different 'cause, like he says, you do it in a different way. (Richard & David, Amber Hill, year 11, set 2)

S: It's different 'cause you have to work it out for yourself, like, you haven't got a book to show you what you've got to do. (Shaun, Amber Hill, year 11, set 1)

The clarity of the students' perceptions on this issue is quite striking, as, although there was no clear consensus about the reasons for the differences between mathematics in and out of school, all of the students interviewed believed that using mathematics within school was a very different experience from using mathematics outside school. Furthermore, the students gave reasons for their ideas of difference which were very close to the ideas proposed by various researchers in the field. George, in set 3, was particularly interesting because he cited the influence of the social situation as the reason for his use of his own methods, in preference to school methods. Lave (1988) has noted the influence of the social situation over adults' choice of methods but George was not only influenced by the social situation, he was also aware of this influence. This suggests that his ideas of meaning and understanding in mathematical situations were very strongly influenced by the social nature of the settings and his statement that 'you're not like in school, it tends to be social, so it would be like *too much change* to refer back to here' gives a clear indication that his perceptions of the environments created by the 'real world' and the mathematics classroom were inherently different.

John and Paul in set 1, also concur with researchers such as Cobb (1986) when they say that: 'they seem more important, worth doing, the things you do outside of school'. These students were able to cite the influence of their motivational goals upon their choice of method which, again, suggests that these goals had a strong influence upon them. It was clear from these students' descriptions that their use of mathematics in situations within and outside school was goal driven and that the goals that were formed were not inherently mathematical. Students described the importance of situations outside of school, the lack of complication, the social nature of the 'real world' and being alone, without books or teachers to help them. These differences caused the students to abandon their school-learned methods.

These students showed that, although they did not make use of school methods in out-of-school situations, they were at least able to think for themselves and invent their own methods. Other students at Amber Hill painted a bleaker picture of their use of mathematics, indicating that their mathematical learning had disempowered them in more insidious ways, even stopping them from inventing their own methods:

> JB: When you use maths outside of school, do you feel the same way as when you are doing maths in school or do they feel different?
> J: They feel a lot different, like, um, you sort of have a little bit of understanding when you're in your lessons but your mind goes totally blank when you're outside.
> JB: Why is that do you think?
> J: You're not around people that understand it, like that can explain it to you and you're just like on your own.... and you haven't got your little book with your notes. (Jackie, Amber Hill, year 10, set 1)

Schoenfeld (1992) lists seven 'typical' student beliefs, one of which is 'the mathematics learned in school has little or nothing to do with the real world' (Schoenfeld, 1992, p359). The views of the Amber Hill students seemed to concur with this assertion. These views clearly limited the usefulness of their school-learned mathematics and, later in this chapter, I will continue my analysis of the different reasons for this. Before doing so I would like to consider the responses of the Phoenix Park students to the different assessments reported in the last chapter and to their GCSE examination.

8.2.2 Phoenix Park

a) Performance patterns

The results of the last chapter provide some indication that the students at Phoenix Park were at least as capable in test situations as the students at Amber Hill. In long-term assessments, significantly more of the Phoenix Park students were able to answer questions correctly six months after their lessons. The difference in performance between the students at the two schools and the difference between Phoenix Park students in year 9 and year 10, on these assessments, indicates that this was due to the way in which students had learned their mathematics. When the students were introduced to standard methods and procedures that they practiced, rather than used, they did not remember many of the procedures six months later. The students who had forgotten the largest proportion of their work were the Amber Hill year 9, set 1 students; they were introduced to their methods at a fast pace, which probably caused this The next largest proportion was forgotten by the Amber Hill year 10 students, who, in turn forgot more than the Phoenix Park year 9 students. The only learning that seemed to have been moderately successful in the long term was that of the Phoenix Park year 10 students, who learned about estimation and statistics when they used these ideas within an applied activity. At Phoenix Park the year 9 fraction investigation was the only piece of work in the school that was two lessons long and that was based around the learning of a set, algorithmic procedure. The statistics project was much more typical of Phoenix Park work, and the successful retention of this work six months after it was encountered was generally consistent with the confidence Phoenix Park students demonstrated in other mathematical situations.

In the two applied assessments the Phoenix Park students did not demonstrate the particular problems that the Amber Hill students demonstrated and the difference in performance of the students at the two schools became more marked as they experienced more of their different school approaches. In year 9, many of the students demonstrated a similar ability to solve problems related to angle and volume, apart from a significant proportion of the high set Amber Hill students who did not appear to interpret the demands of the situation well. In year 10 the differences were more striking and the Phoenix Park students were significantly more able to produce good flat designs that incorporated their knowledge of measurement and scale, and then succesfully solve problems related to angle and area. They also demonstrated a freedom in approach that the Amber Hill students did not seem to possess. I would now like to propose that the enhanced success of the Phoenix Park students derived from a capability and willingness that they had developed to think mathematically in different situations and to interpret the demands of varied settings.

b) Interpreting the demands of situations

At Phoenix Park the students were interviewed in year 11 a few weeks after completing their mock GCSE examinations. At this time the students had experienced a few weeks of their examination preparation approach. This meant that projects had been abandoned and students had moved to a more formal and procedural system of learning. In interviews the students reported that they found the GCSE mock examination difficult, but the students' concerns, which were reported in the last chapter, were completely different from those expressed by the Amber Hill students. The students were concerned that the examination included mathematical notation and content areas that they had not met before, that their projects were difficult to revise from, that they did not receive any pressure to revise and, for some of them, that they did not have calculators. Despite the differences between the nature of the students' project work and the GCSE examination, the students at Phoenix Park did not report that they could not apply the methods they had learned, or that they could not interpret the questions when they did not contain clues. Rather, the students reported that when they had learned the mathematics assessed they were able to make use of it:

> JB: How did you get on in your mocks?
> H: OK, it wasn't really hard.
> JB: Did you find that the questions were different to what you were used to?
> H: Well a lot of the stuff we hadn't done, until now, that's what we're doing now.
> JB: And when you came across a question where it was something you had done, did you feel you were able to do the question?
> H: Yes, I found it easy. (Hannah, PP, year 11, JC)

The Amber Hill students that were given similar interview questions responded very differently:

> JB: And what about the questions that you could remember doing, when you recognised what to do, did you feel able to do those questions?
> G: I still couldn't do them, because they were different, I couldn't apply the methods properly. (Carly Amber Hill, year 11, set 1)

The reports of the students at Phoenix Park given in the last chapter show that they faced a number of disadvantages that may have diminished their examination performance, but they still attained higher grades than the Amber Hill students. The reason for this appeared to be that students could make use of the mathematics they had learned when it was assessed and even though they had not covered everything they needed for the examination, they could make effective use of the mathematics they had encountered before. The superior performance of the Phoenix Park students on conceptual questions also provides an important clue as to the reason for their general success. The students were able to use mathematics in different situations because of their attitudes towards and beliefs about mathematics. When the students approached questions, they believed that they should consider the situations presented and interpret what they needed to do:

JB: Can you tell me about anything you like about maths?
T: I think it allows .. when you first come to the school and you do your projects and it allows you to think more for yourself then when you were in middle school and you worked from the board or from books.
JB: And is that good for you do you think?
T: Yes.
JB: In what way?
T: It helped with the exams where we had to ... had to think for ourselves there and work things out. (Tina, PP, year 11, RT)

The students were not inhibited in the way that the Amber Hill students were. They were not struggling to remember set procedures, nor search for cues which may indicate the procedures to use. They were free to consider the different questions and make sense of them:

JB: Did you feel in your exam that there were things you hadn't done before?
A: Well, sometimes I suppose they put it in a way which throws you, but if there's stuff I actually haven't done before I'll try and make as much sense of it as I can, try and understand it and answer it as best as I can, and if it's wrong, it's wrong. (Angus, PP, year 11, RT)

The Phoenix Park students were willing to try and think mathematically about questions and work out what was needed. This willingness appeared to derive from their belief in the value of thought in mathematics. Unlike the Amber Hill stud nts they did not believe that mathematical success depended upon learning different procedures:

JB: Is there a lot to remember in maths?

S: There's a lot to learn, but then you need to know how to understand it and once you can do that, you can learn a lot.

P: It's not sort of learning is it?, it's learning how to do things.

S: Yes, you don't need to learn facts, in the beginning of the maths paper they give you all the equations and facts you need to know. (Philip & Simon, PP, year 11, JC)

Lave (1996a) has claimed that notions of knowing should be replaced with notions of doing, in order to acknowledge the relational nature of cognition in practice. The Phoenix Park students seemed to believe in this relational view of knowledge, as illustrated by the distinction drawn out by Paul : 'It's not sort of learning is it?, it's learning how to do things'. This comment also highlights the difference between the Amber Hill and Phoenix Park approaches. At Amber Hill teachers tried to give the students knowledge, at Phoenix Park the students 'learned how to do things'. There was a marked contrast between the beliefs of these students and the Amber Hill students who thought that they needed to remember a vast number of rules and procedures. It was this difference in belief that may have caused the variation in the students' use of mathematics in the GCSE examination and in the applied assessments. The students at Phoenix Park were not restricted by the need to remember algorithms and procedures:

JB: How long do you think you can remember work after you've done it?

G: Well I have an idea a long time after and I could probably go on from that, I wouldn't remember exactly how I done it, but I'd have an idea what to do. (Gary, PP, year 11, MC)

Here Gary also supports a relational view of knowing, he dismissed the view that knowledge existed in his head ('I wouldn't remember exactly how I done it') and stated that his knowledge would only be *informed* by previously held ideas, he would 'go on from that' and form ideas of what he had to do in different situations. The students at Phoenix Park only needed to remember an idea and move on from that, which may not have been as difficult as trying to remember a complex set of algorithms and procedures. This would also fit with the superior performance of the year 10 students using statistics over the year 9 students trying to recall a long division algorithm. At Phoenix Park the students seemed to have developed the ability to think holistically about the requirements of situations, probably because they needed to do this in their projects. They were prepared to think about questions, even if they did not know, or remember, any set procedures to use. This approach will probably have contributed towards their superior performance on the conceptual questions in the examination and on applied and long term assessments. The equivalent performance of both sets of students on procedural GCSE questions, despite the

Amber Hill students' motivation, examination preparation and commitment to learning procedures, must also have been due to the willingness of the Phoenix Park students to think for themselves and work out what they needed to do in procedural questions.

c) Using mathematics in the 'real world'

All of the students interviewed at Amber Hill (n = 40) reported that they used their own methods in 'real world' situations and they invented these because they could not relate school methods to real situations. At Phoenix Park the picture created by the students was very different and over three-quarters of the students interviewed (n = 36) said that they used their school learned methods in situations outside school. This seemed to be because they did not regard the mathematics they learned in school as inherently different from the mathematics of the 'real world':

> JB: Can you think of a time outside school when you've had to do something mathematical ever?
> T: I do sometimes when I'm at home and I have to work out like prices and stuff, that's when I use it.
> JB: And is it similar or different to the way you do maths at school?
> T: Similar.
> JB: Do you find the maths you do in school helpful?
> T: Yes.
> JB: What do you think?
> L: Yes and sometimes you use it in other lessons in school, like in IT you use it sometimes. (Tanya and Laura, Phoenix Park, year 10, MC)

> JB: When you do something with maths in it outside of school does it feel like when you are doing maths in school or does it feel different?
> G: No, I think I can connect back to what I done in class so I know what I'm doing.
> JB: What do you think?
> J: It just comes naturally, once you've learned it you don't forget. (Gavin and John, Phoenix Park, year 10, MC)

When I asked the students at Phoenix Park the same questions as the students at Amber Hill, about their use of school-learned methods or their own methods, three-quarters of the students chose their school learned methods (n = 36), this compared with none of the 40 Amber Hill students:

JB: And when you use maths in situations outside of school do you use the methods you have learned in school or do you tend to use your own?

T: Use those maths what I've learned here. (Tina, Phoenix Park, year 11, RT)

A: What we've learned here probably has been helpful and I would probably look back and use that. (Angus, Phoenix Park, year 11, RT)

G: I'd probably try and use what I've learned in school.

I: So would I. (Ian & Gary, Phoenix Park, year 11, JC)

D: Probably try and think back to here and maybe try and think of my own methods sometimes, depending what sort of situation.

JB: So you would think back here for some things?

A: Yes it would be really easy to think back here.

JB: It would?

A: Yes.

JB: Why do you think that?

A: I dunno, I just remember a lot of stuff from here, it's not because it wasn't long ago, it's just because .. it's just in my mind. (Danny & Alex, Phoenix Park, year 11, JC)

The students also reported that they made use of their school learned mathematics in a variety of different situations:

JB: Can you think of a time when you've used maths when you've been out of school?

G: Yes.

JB: What sort of situation?

G: My job at the Co-op

JB: And you use maths there?

G: Yes.

JB: Do you find that you can?

G: Yes, it's easy. (Gary, Phoenix Park, year 10, MC)

JB: Can you think of a time in your everyday lives when you've had to use something mathematical, any sort of maths?

I: I think a lot of the time you use it without noticing.

JB: Do you ever find yourself in a situation when you need to use some maths but you can't remember how to do it, or do you find that you're using things you've learned?

I: Yes.

JB: Which?

I: I use what I've learned. (Ian, Phoenix Park, year 10, RT)

N: Maths is a bit like integrated humanities.
JB: Why?
N: Because we use maths things there and humanities things here. (Nicola, Phoenix Park, year 11, RT)

A: It's structured so that .. it helps with other subjects like science, the results and drawing conclusions, it helps develop those skills. (Alex, Phoenix Park, year 11, JC)

Although the students at the two schools were only giving their reports of their use of mathematics, these reports were consistent with the mathematical behaviour they demonstrated in other situations. The Amber Hill students' descriptions indicated that they saw little use for the mathematics they learned in school in out-of-school situations and so, in 'real world' mathematical situations, they abandoned their school-learned mathematics and invented their own methods. The students appeared to regard the worlds of the school mathematics classroom and the rest of their lives as inherently different. This was not true for the Phoenix Park students who had not constructed boundaries around their school mathematical knowledge in quite the same way. This idea will be developed further in the last section of this chapter.

In the next section I will aim to show that the differences between the ideas and understandings of the Amber Hill and Phoenix Park students were indicative of two different forms of learning and that these differences support an emerging perspective within the field of situated cognition.

8.3 Different Forms of Learning

8.3.1 Amber Hill

Whitehead (1962) describes the type of knowledge that the Amber Hill students seem to have developed as inert, because it could only be recalled when it was specifically asked for. Schoenfeld (1985) asserts that students develop this type of knowledge in response to conventional pedagogic practices in mathematics that demonstrate set routines which should be learned. These practices, he suggests, cause students to develop a procedural knowledge that they can only use in standard textbook situations. In less procedural situations students are forced to base their mathematical decision making upon irrelevant features of questions such as the format they are presented in or the key words used

(Schoenfeld, 1988). The behaviour described by Schoenfeld characterised the Amber Hill students' response to *different* mathematical demands very well. The students had developed an inert, procedural knowledge and the reason for this seemed to be that the students had learned the teachers' methods and rules without really understanding them. This meant that in real or applied situations the students were forced to look for cues which may indicate what they had to do.

The teachers at Amber Hill encouraged students to learn the set methods they gave them because they thought that this would make the subject clearer and easier for students. The students would not need to interpret the situations and understand what was going on as long as they could remember a procedure they had learned. When the teachers prepared the students for the examinations they encouraged them to rehearse the rules they had taught them, rather than to think mathematically about the situations presented:

> M: It's different to when you read them in the book, like he told us, sir told us that in our exam we don't look at the story, we just look at the numbers. (Marco, AH, year 11, set 4)

The students were trained to ignore the situations presented and to perform procedures with the numbers. It was not surprising then that their behaviour appeared to be so cue-based. In the examination, and in applied assessments, students were forced to look for cues because they had no other way of knowing what to do. They were not prepared to interpret the mathematical demands of the situations and they had not learned what different procedures meant or how they may adapt them or change them if they needed to. They did not know which procedures to choose, nor whether they were effective or correct having chosen them:

> S: You've got to.. just like a computer, you'll do it, but when you get the answer you won't be sure that it's right, if it's like, you'll be like - this is how we learnt it, but is this the answer? you're never certain. (Simon, AH, year 11, set 7)

> JB: Could you do the questions?
> S: No, I couldn't, sometimes you can, but when it comes to really complicated ones you forget it and then you have to ask the teacher to go over it again and you think - I remember all this but you don't really remember what the point was. (Suzy, AH, year 11, set 2)

Both of these comments seem important. Simon describes how he had learned procedures and even used procedures, with no or little understanding of what they meant and Suzy captures the essence of the problem: the students remembered what to do, but they did not really remember what the point was. The Cognition and Technology Group at Vanderbilt (1990) describe the way in which different teaching approaches affect the way students view mathematical concepts and procedures. They report that problem-oriented approaches to learning help students to view mathematical concepts as useful tools that they can use in different situations. More traditional approaches to learning cause students to view concepts 'as difficult ends to be tolerated rather than as exciting inventions (tools) that allow a variety of problems to be solved' (CTGV, 1990, p3). Brown, Collins & Duguid (1989) draw similar distinctions between authentic and algorithmic approaches to teaching and the effect these have upon the way students view mathematical concepts and procedures. The algorithmic approach experienced by the Amber Hill students caused them to view the procedures they had learned as abstract entities, useful only for solving school textbook questions. They did not hold the view that the algorithms they had learned were exciting and useful inventions that would give them the opportunity to solve different mathematical problems. The students' mathematical learning seemed to have created an important distinction in their minds between what they perceived as the algorithmic demands of school mathematics and the completely separate demands of the 'real world':

> JB: When you use maths out of school, does it feel different to using it in school or does it feel the same?
> R: Well, when I'm out of school, the maths from here is nothing to do with it to tell you the truth.
> JB: What do you mean?
> R: Well, it's nothing to do with this place, most of the things we've learned in school we would never use anywhere. (Richard, AH, year 11, set 2)

The difficulties the students experienced using mathematics in the examination and in applied assessments, combined with their reported views on the irrelevance of school-learned mathematics, make it seem unlikely that the students would make use of much of their school-learned mathematics in 'real world' situations. Theories of situated cognition challenge the view that performance in one social setting can be taken as an indication of performance in another, because individuals form meanings in relation to the settings they are in. However, whilst we may not know what the Amber Hill students would do in real world situations, there were clear indications of what they would not do, and that was make use of their school-learned methods. This is because the students had not developed a mathematical understanding which would allow them to form insights into the usefulness and appropriateness of their different methods in real situations. Indeed, the GCSE examination was probably closest in nature and demand to their textbook questions than anything else they would ever encounter, but they could not relate their school-learned methods even to this. Given the students' responses to this examination, it seems hardly surprising that they abandoned their school-learned methods in the 'real world' and that they failed to perceive their relevance.

What I have tried to show here is that much of the students' learning was inert (Whitehead, 1962), because of the students' perceptions about mathematics and, related to this, their interpretation of situations. Resnick (1993) has suggested that many sociological theories lead to the belief that the main thing people learn in school is how to behave in school. This seemed to be true for the Amber Hill students: in lessons the students tried to interpret what to do from the cues presented in questions, and were often successful in doing so. In applied assessments the students tried to do what was right, for example, demonstrating their knowledge of trigonometry in a question on angles, performing exact area calculations in a question on floor space. The students used the words 'angle' and 'area' as cues, rather than thinking holistically about the requirements of the questions. In the examinations the students tried to interpret cues in a similar way, but found this to be very difficult. In none of these situations did the students think mathematically, they did not think about the situations holistically and think about the mathematics to use. This was partly because of their perceptions about mathematics and partly because the students' learning was fixed, inflexible and tied to the textbooks they had learned it in. It is because of this that I believe they could not use it in the 'real world'. This is not to say that the students could not use mathematics outside school. As they reported, they invented their own methods in real situations and tried to work things out. But it does show that the learning they developed at school was not useful in new and different situations and the methods and procedures the students learned were of limited use. In the 'real world' and in employment situations the students would be left to 'learn on the job':

> JB: So you've been doing roofing for about a year? - there's quite a lot of maths involved in that isn't there?
> R: Well, when I started that I was... when I got there, to be honest with you I was - what??, you know?, it was like centimetres and inches and feet and angles and .. like that, you know? and I was just - what?? But now I pick things up as I go along.
> (Richard, AH, year 11, set 2)

After the motivation the students demonstrated in their mathematics lessons and their desire to learn mathematics because of their beliefs about its importance, this total lack of preparation for the mathematical demand of the 'real world' must be considered to be unfair. The students' performance in applied assessments and their reports of their use of mathematics in different situations should also raise serious questions about the utility of their learning for anything other than working through textbooks.

8.3.2 Phoenix Park

The students at Phoenix Park were considerably more confident in their use of mathematics in new and real situations than the students at Amber Hill and they related this confidence to the approach of the school:

> L: Yeah when we did percentages and that, we sort of worked them out as though we were out of school using them.
> V: And most of the activities we did you could use.
> L: Yeah most of the activities you'd use - not the actual same things as the activities, but things you could use them in.
> JB: If you were in a situation outside of school and you needed to use some maths do you think you would remember back to things you have learned here or do you think you would use your own methods?
> L: Um, sometimes I know I have changed methods to make it easier for me - if you find it easier the way you learned it then you keep the same, whatever's easiest. (Vicky & Lindsey, PP, year 11, JC)

The students gave indications that the mathematics they learned through their project-based work was useful in new and different situations. This seemed to derive from a way of thinking and working in which the students learned to adapt and change methods to fit the demands of different situations. This again supports a situated view of learning (Lave, 1993), because the students described the way in which they developed meaning in interaction with different settings. Lindsey said that she would use mathematics 'not the actual same things as the activities, but things you could use them in', she would adapt and transform what she had learned to fit new situations. Later in the interview she said:

> L: Well if you find a rule or a method, you try and adapt it to other things, when we found this rule that worked with the circles we started to work out the percentages and then adapted it, so we just took it further and took different steps and tried to adapt it to new situations. (Lindsey, PP, year 11, JC)

The analysis offered by Lindsey in this extract is very important, for it was this willingness to adapt and change methods to fit new situations which seemed to underlie the students' confidence in their use of mathematics in 'real world' situations. Indeed many of the students' descriptions suggest that they had learned mathematics in a way that transcended the boundaries (Lave, 1996a) which generally exist between the classroom and real situations.

> J: Solve the problems and think about other problems and solve them, problems that aren't connected with maths, think about them.
> JB: You think the way you do maths helps you to do that?
> J: Yes.
> JB: Things that aren't to do with maths?
> J: It's more the thinking side to sort of look at everything you've got and think about how to solve it. (Jackie, PP, year 10, JC)

The idea that students may have developed a usable form of mathematics in response to their project work was partly supported by the students' views about the nature of their bookwork. When they described the mathematics they learned in SMP books at middle school, the mathematics they learned through their projects at Phoenix Park and the examination revision of year 11; the contrast they offered between the three approaches centred around the adaptability of their learning:

> JB: Do you think you learn different things - doing activities and working from a book?
> L: I think you tend to understand it more when you do it with the activities.
> V: 'Cause you're trying to work it out.
> L: Yeah and you understand how they got it, when you're working from a book, you just know that's the thing and that you just stick to it, you tend to understand it more from the activities. (Vicky & Lindsey, PP, year 11, JC)

> JB: If you were in a job situation or something outside of school and there was something mathematical you had to do, do you think you would think back to things you'd learned here and use that?
> L: I wouldn't be able to use the stuff now because I don't understand it. (examination preparation)
> H: No, we only understand it as in the way how, what it's been set, like this is a fraction, so alright then.
> L: But, like Pope's theory I'll always remember - when you had to draw something I'll always remember the, like the projects we used to do.

H: Yeah, they were helpful for things you would use later, the projects. (Helen & Linda, PP, year 11, MC)

When Helen says that 'we only understand it as in the way what it's been set' she seems to be describing the inflexible nature of her learning, but she contrasts this with her project work which she regarded 'as helpful for things you would use later'. Lindsey also seems to be describing the implicit boundaries which surround bookwork when she says 'you just know that's the thing and you just stick to it' and Helen talks in similar terms: 'like this is a fraction, so alright then'. As part of the Phoenix Park examination preparation the students were introduced to rules and procedures. They, like the Amber Hill students, regarded these rules as 'set' and unchangeable. These descriptions contrast with Lindsey's earlier statement about project work: 'well if you find a rule or a method, you try and adapt it to other things'.

There were a number of indications that the students at Phoenix Park had developed a predisposition to think about and use mathematics in new and different situations and this seemed to relate to a general mathematical empowerment. This empowerment meant that they were flexible in their approach and they were prepared to take what they had learned and adapt it to fit new situations. This flexibility seemed to rest upon two important principles. First, the students had the belief that the mathematics they learned was adaptable. Many researchers have shown the rigid and inflexible models of mathematics that students develop which stop them from using mathematics in new situations (Young, 1993; Brown, Collins & Duguid, 1989; Schoenfeld, 1985). The comments given by Phoenix Park students in chapter 6 demonstrated that they viewed mathematics as an active, exploratory and adaptable subject. The second important feature of their learning was the ability they appeared to have developed to adapt and change methods and to think mathematically.

T: Yes, when I go shopping I just ... get all the things in the basket, number them all at a pound, for example if some of them are 50p and some of them are £2, I just call them all a pound and see how much I've got in my pocket, then hope for the best. It usually gets me...it's worked every time actually.

JB: That's not a bad strategy if some of the prices are more and some less.

T: Yes, you've just got to make sure that there's more that are less than a pound than more than a pound or else you haven't got enough money. (Trevor, PP, year 11, RT)

Trevor was not describing any complex mathematical thinking in this extract, but his description was interesting for two reasons. First Trevor chose this situation as an example of the way he used his school-learned mathematics in the 'real world', second his statement demonstrates the confidence he had to think mathematically in a 'real' situation. The students were very clear in interviews about the source of their mathematical confidence. This they related to two features of their approach. One, the fact that they had been forced to become autonomous learners. The second, which was related to this, was the fact that they had always been encouraged to think for themselves:

> N: You had to be self-motivated.
> JB: Is that fair do you think?
> N: Well, it was good for us because it taught us to do things by ourselves so it made you confident to do things for yourself. (Nicola, PP, year 11, RT)

> JB: Did doing the project work help you in any way do you think?
> T: Yes, thinking for yourself and motivating yourself I think. (Tina, PP, year 11, RT)

> S: At the start of year 9, the teacher told you what to do and explained all the skills and you just did it and then gradually you begin to think more for yourself - you know - what shall I do next?, what shall I do about this? (Simon, PP, year 11, JC)

The students contrasted their experiences of project work and bookwork by saying that project work required them to work things out and think, whilst bookwork or boardwork did not:

> T: I think it allows, when you first come to the school you do your projects and it allows you to think more for yourself than when you were in middle school and you worked from the board or from books, things like that. (Tina, PP, year 11, RT)

> A: With the SMP books it just sort of ... say you were doing the SMP books on percentages or something, it would just ask you a series of questions on it, like find the percentages of this and that, but if you did an investigation on it, you would have to like think a lot more about it for yourself and how to like solve the problem. I would say it's a lot more interesting than doing SMP books. (Angus, PP, year 11, RT)

This requirement to 'think' in mathematics lessons was central to Phoenix Park's approach. The students were given very little structure and guidance and although many spent long periods of time off task, when they were working, they needed to be thinking. It was almost impossible for the students to switch off and work in a procedural way when they were planning and developing their projects. For some students this was the most important difference between their bookwork and project work:

G: In books it more or less explains everything to it, but I'd rather work it out by myself by looking at it and working it out or getting the teacher to talk to you about it, instead of telling you exactly what to do.
I: And in the books you don't understand it.
G: And you take it in if you've done it but if you read it, you just read it and you don't take any notice. (Ian & Gary, PP, year 11, JC)

H: The stuff we're doing now, it's more fractions and figures. (examination preparation)
L: Like we'll do a lesson or something and some of us don't understand it and then next lesson we'll do something completely different, that's harder and you can't remember anything.
H: Yeah, that's true - it's a bit sort of chop and change, you don't go into anything in depth, which was better.
JB: Can you recognise the work you're doing now as the same maths as before but in a different way?
H: Some of it.
L: I can't.
JB: It just seems different?
L: Yeh.
JB: But things like fractions must have come up before?
H: Yeh but not like this.
JB: So what's different?
L: We were using them before, but now we're just writing them.
H: And vaguely understanding them and having a little bit of discussion and thinking oh I don't understand that or I understand this and then you just leave it, but I'd say some of the work we did before we do use now or out of school or whatever. (Linda & Helen, PP, year 11, MC)

The difference for Linda, between bookwork and project work was 'we were using them before, but now we're just writing them', Gary drew out a similar distinction saying 'you take it in if you've done it, but if you read it you just read it'. Helen chose to say, without prompting or asking, that she used the mathematics she learned through the projects 'now or out of school or whatever'. Perhaps the most important distinction of all, between bookwork and project work, was provided by Sue:

JB Do you think when you use maths outside of school, it feels very different to using maths in school, or does it feel similar?

S: Very different from what we do now, if we do use maths outside of school it's got the same atmosphere as how it used to be, but not now.

JB: What do you mean by - it's got the same atmosphere?

S: Well, when we used to do projects, it was like that, looking at things and working them out, solving them - so it was similar to that, but it's not similar to this stuff now, it's, you don't know what this stuff is for really, except the exam. (Sue, PP, year 11, MC)

Sue, was particularly lucid in her comparison of the two approaches - one was about solving problems, 'looking at things and working them out, solving them', the other did not hold any meaning for her - 'you don't know what this stuff is for really, except the exam'. Sue, like other students, distinguished between the two approaches in terms of the usefulness of the mathematics she had learned. One version was similar to the mathematics of the 'real world', the other was not.

8.4 Discussion and Conclusion

The relative underachievement of the students at Amber Hill, in formal test situations, may be considered surprising, partly because the students were very motivated in mathematics lessons and partly because the school's mathematical approach was extremely examination-oriented. However, after many hours of watching the students work at Amber Hill and talking to the students in interviews I was not surprised by the relative performance of the two sets of students. This was because the learning of the Amber Hill students was extremely inflexible and inert and although many were able to use their mathematical methods within the textbook questions that followed them, when the demands of situations were even slightly different to the ones they were used to, they failed. They had developed a knowledge that only appeared to be effective in other textbook or similar situations. I would relate this problem to three aspects of their learning. First, they were not encouraged to think about or understand the methods they used in class, so they were not able to consider the methods they had learned and make informed decisions about the ones they should use. Second, they believed that mathematics was about remembering methods, rather than thinking about questions. In class they had all been taught to learn methods and to practice them, not to adapt them or think about them. The third problem seemed to be caused by the students' perceptions of the mathematics classroom as a distinct 'community of practice' (Lave, 1993, 1996a) in which mathematical rules and procedures were learned that were specific to that community of practice.

At Phoenix Park the students were probably less motivated to do well in examinations. They spent less time on task in lessons, they had not been introduced to all of the content and procedures they needed in the examination and they were not even given the necessary equipment for the examination. But the students were more successful in the examination, and in applied and long-term assessments, apparently because they had developed a different form of learning. The nature and form of this learning is interesting to consider, particularly in the light of new developments in the field of situated cognition which have gone some way towards outlining the qualities of learning that enhance or inhibit its usefulness.

The situated cognition perspective has been instrumental in raising awareness of the importance of the situation and culture in which learning is encountered. Situated cognition theorists have provided important perspectives on the relative influence of knowledge, memory, notions of transfer and the social situation upon the way individuals repond to different situations. Gibson (1986) is cited as providing the most extreme position on situated learning (Young, 1993). Gibson (1986) asserts that when individuals develop meaning from situations, they do so through a process of 'perceiving and acting' and by creating meaning on the spot, rather than by using their memory of representations stored in the head (Gibson, 1986, p258). Young suggests that, in Gibson's theory 'the concept of memory becomes non-existent or irrelevant to an explanation of knowing and learning, replaced by an emphasis of the tuning of attention and perception' (Young, 1993 p 44). There is some debate as to whether Gibson replaced or just repositioned the importance of memory (Greeno, Smith & Moore, 1993) but the students' descriptions of their learning at Phoenix Park suggest that their success in new situations was due to their ability to perceive and interpret what was needed from situations *combined with* their ability to adapt and make use of the procedures they had learned. From this perspective, perception and interpretation of situations becomes the *key* to effective learning, partly because this development of meaning enabled the students to reflect upon prior experience. For whilst I agree with Gibson's suggestion that meaning is generated 'on the spot' I would suggest that the way in which this was made possible for the Phoenix Park students was that their thought and interpretation enabled their memory of the mathematics they had used before to be enacted.

Lave (1996a) asserts that students do not use mathematics learned in one situation in another situation because the two situations represent different 'communities of practice'. The students relate to them differently and form different ideas in relation to the two settings. This analysis is similar to one offered by Bernstein (1971) in which he suggests that educational knowledge is 'uncommonsense knowledge' (p58) and that children are socialised early in their lives into knowledge frames which discourage connections with everyday realities. Lave asserts that when students do use mathematics developed in one setting in another setting, it is because they have perceived and interpreted the settings in a similar way and formed similar representations and meanings in the two settings. This view appears to be consonant with the views of the Phoenix Park students. When the Phoenix Park students reported their successful use of mathematics, they focused upon the way that they thought about mathematics in different situations, interpreted what was needed and formed ideas in relation to their setting. They refuted the idea that they had used knowledge learned at school in the same form elsewhere.

Lave proposes that transfer is an impoverished and inadequate concept that cannot explain the way individuals act in different settings (1988, 1996a). She, and others in the field of situated cognition, have suggested that knowledge should be represented as an interpretation of experience and that distinctions should not be drawn between knowledge and the way people perform in different settings. In this view knowledge is constructed in different situations, it is not transferred from one situation to another and it is not regarded 'as a process of taking a given item and applying it somewhere else' (Lave, 1988, p37). The Phoenix Park students seemed to add support to this notion because they indicated that they were not transferring knowledge but constructing it in relation to the situation they were in. Lave proposes that notions of knowledge should be replaced with notions of doing and the Phoenix Park students seem to have developed a similar view:

> P: It's not sort of learning is it?, it's learning how to do things. (Philip, PP, year 11, JC)

The ability of the Phoenix Park students to use mathematics in different situations can be taken as some support for the use of cognitive apprenticeship approaches in classrooms. This is because the reason the students seemed able to use their mathematics was not because they had learned it in a clear and straightforward way, but because they had used mathematics in a similar way in the classroom. They had been apprenticed into this type of mathematical use. As Sue said, when they used mathematics outside of school, it felt the same, it 'had the same atmosphere' as their project based mathematics. Even the vast differences between the nature of Phoenix Park's open-ended projects and the GCSE examination, did not faze the students. This was because they did not regard the two assessments as inherently different:

> JB: Did the questions in the exam seem similar to what you'd done in class or did they seem different?
> L: Most of them seemed similar didn't they?
> JB: The mock was similar to your project work?
> L: Most of it seemed the same really. (Louise, PP, year 11, JC)

Within school the Phoenix Park students did not view mathematics as a formalised and abstract entity that was only useful for school mathematics problems. They had not constructed boundaries (Siskin, 1994) around their school mathematical understandings in the way that the Amber Hill students had. At Amber Hill the students developed a narrow view of mathematics that they regarded as useful only within classroom textbook situations. The students regarded the school mathematics classroom as one 'community of practice' (Lave, 1993, 1996a) and other places, even the school examination hall as different communities of practice.

Lave (1996a) claims that learning would be enhanced if we were to consider and understand how barriers are generated that make individuals view the worlds of school and the rest of their lives as different communities of practice. At Amber Hill there were strong institutional barriers which separated the students' experiences of school from their experiences of the rest of the world. Many of these barriers were constituents of Bernstein's visible pedagogy (Bernstein, 1975). General school rules and practices such as school uniform, timetables, discipline and order contributed to these as well as the esoteric mathematical practices of formalisation and rule following. At Phoenix Park the barriers between school and the real world were less distinct: there were no bells at the school, students did not wear uniform, the teachers did not give them orders, they could make choices about the nature and organisation of their work and whether they worked or not, mathematics was not presented as a formalised, algorithmic subject and the mathematics classroom was a social arena. The communities of practice making up school and the real world were not inherently different. The importance of the students' perceptions about the formality of the mathematics classroom was shown very clearly by George's comment given earlier:

> G: I use my own methods.
> S: Yeah.
> JB: Why is that do you think?
> G: 'Cause when we're out of school yeah, we think, when we're out of school it's *social*, you're not like in school, it tends to be social, so it would be like too much change to refer back to here. (George, Amber Hill, year 10, set 3)

In the mathematics classrooms of Phoenix Park talk, discussion and negotiation were intrinsic features of the students' work. At Amber Hill the students were allowed to talk to their partners as they worked, but the students clearly did not view the mathematics classroom as a social place. This was important, partly because the Amber Hill students experienced less opportunity to derive meaning through a discussion of mathematical concepts and partly because this contributed towards the students' perceptions of difference. George gave a clear indication that he regarded the classroom and the rest of the world as different communities of practice and this meant that the mathematics he learned in school was of no use to him outside of school. From this perspective, the Phoenix Park students were more able to make use of their school learned mathematics because they had been enculturated into a practice of thinking, talking, representing and interpreting in the classroom. The students' knowledge of mathematical procedures at the two schools may have been similar but the way they connected and interacted with mathematics and formed mathematical relations was different, due to the way that they had been enculturated or apprenticed at school.

It was the perceiving and interpreting of situations that seemed to characterise the main difference between the students at the two schools. When the students were presented with the angle problem in the architectural task, many of the Amber Hill students were unsuccessful, not because they were not capable of estimating an angle, but because they could not interpret the situation. The Phoenix Park students were able to do this, presumably because they had experienced similar demands in the classroom. Similarly, in the flat design task, 25 Amber Hill students could not work out the area of their flat, not because they were incapable of calculating areas, but because they did not interpret what was needed in the situation. The Phoenix Park students, on the other hand, were not as well versed in mathematical procedures, but they were able to interpret and develop meaning in the situations they encountered. The fact that the Amber Hill students had learned more procedures than the Phoenix Park students demonstrates the inadequacy of transfer theories in explaining individuals' use or non-use of subject matter. This is because the Amber Hill students' non-use of mathematics had nothing to do with the knowledge of procedures they did or did not own. Similarly, the Phoenix Park students effective use of mathematics must be taken as a support for a relational view of learning, because it was the students' ability or pre-disposition to think and form meaning in different settings that differentiated them from the Amber Hill students.

I do not wish to present the learning of the students at the two schools in a polarised way, by suggesting that all of the Amber Hill students had developed a shallow, procedural knowledge, whilst all of the Phoenix Park students were able to use mathematics effectively. At Phoenix Park some of the students persisted in the belief that they needed to learn set rules and methods in order to be successful mathematicians. Others took to the open approach and flourished within it. I have not found it possible to find out why different students responded to the Phoenix Park approach in different ways, but it is not surprising that some students resisted the open nature of the mathematics when they had learned mathematics in a very different way for eight years prior to attending Phoenix

Park and they were only at Phoenix Park for three years. Similarly, at Amber Hill, some of the students developed an effective mathematical understanding, because they were able to look beyond what they were given and make their own sense of the different methods they encountered. I do not therefore wish to suggest that the two approaches represent opposite ends of a spectrum of mathematical effectiveness. My aim in offering a comparative account of the two approaches is to highlight the distinctive elements of the two approaches and illuminate the potential of the different methods of teaching for the development of different forms of learning.

The data presented in this and the previous chapter lead to a number of possible conclusions that I have set out below:

1) When students are taught mathematical procedures, but they are not encouraged to locate these within wider mathematical perspectives, they can only develop a 'procedural' knowledge (Hiebert, 1986; Schoenfeld, 1985) and this knowledge is extremely limited in its applicability. The lack of understanding that the Amber Hill students had of the different methods they used in class also meant that they found it very difficult remembering methods and using them, even in textbook questions, a few weeks after their original textbook lessons. The students often got by in lessons by interpreting SMP cues (Schoenfeld, 1985), but they found that similar cues were not present within authentic tasks, conceptual GCSE questions or non-school situations.

2) The absence of set procedures and algorithms from the Phoenix Park students' knowledge may have given them the freedom to interpret situations and develop meaning from them. It could be that it was the Amber Hill students' knowledge of rules and algorithms that inhibited their ability to interpret the different situations they encountered. This is a tentative suggestion, but it is supported by a research study conducted by Perry (1991). In this experimental study Perry compared principle-based and procedure-based instruction. This showed that the two types of instruction led a comparable number of children to learn mathematical concepts, but the principle-based instruction led significantly more students to 'transfer' their knowledge to new situations. Perry then repeated the study with an additional type of instruction which combined principles and procedures. In this instruction students were given procedures to learn, but they were also taught about the principles behind them. These students performed in a virtually identical way to the procedure-only students. Perry concluded from this that when students were exposed to procedures they ignored the 'conceptually rich information inherent in the principles' (Perry, 1991 p449). This, and some of the students' responses at the two schools, could suggest that the Phoenix Park students' ability to interpret different situations was enhanced because of their lack of knowledge of standard

mathematical rules and algorithms. These may have served as barriers or boundaries (Bernstein, 1971; Siskin, 1994) for the Amber Hill students which contributed towards the formation of distinct communities of practice (Lave, 1993, 1996a).

3) The largely procedural nature of the mathematics GCSE examination and the requirement of teachers to prepare students for this examination may have detracted from the Phoenix Park students' mathematical understanding. This is also a tentative suggestion, based upon the Phoenix Park students' responses to their examination preparation. The Phoenix Park students, like the Amber Hill students, reported that they were confused by the different 'rules and equations' they were introduced to and, like the Amber Hill students, they could not see their relevance for anything other than the examination. Chapter 6 also demonstrated that the students' examination preparation had caused them to narrow their views of mathematics.

4) The use of cognitive apprenticeship approaches in classrooms has represented an interesting, but slightly incongruous development. This is mainly because the cognitive theorists involved are committed to a perspective, heavily influenced by Vygotsky (1978) and activity theory (Leont'ev, 1981) which essentially acknowledges the importance of the social context in which learning is developed and the goals, purposes and intentions of individuals developed in interaction with their settings. Despite the centrality of the social context to this model, researchers have found it possible to replace real social contexts with the artificial ones of school and transport some of the positive features of cognitive apprenticeship into classrooms. Early indications are that these 'realistic' approaches to learning (see, for example, the Jasper series, developed by the The Cognition and Technology Group at Vanderbilt, (CTGV) 1990) are successful, although little systematic evaluation of learning outcomes has been reported. The students' mathematical capabilities and perceptions at Amber Hill and Phoenix Park seem to add further support to some of the features of classroom cognitive apprenticeship, such as authenticity and the need to use mathematics. This is because the introduction of mathematical ideas as part of meaningful activities seemed to enable the Phoenix Park students to develop an inherent understanding of the meaning of the procedures they encountered. The students formed a belief in the utility of the mathematical procedures they used and they learned to regard them as adaptable and flexible. They experienced mathematics on many different levels and they learned to interpret situations and develop mathematical ideas in relation to a range of different settings. The understandings and perceptions that resulted from this apprenticeship or enculturation seemed to lead to an increased competence in new and unfamiliar situations. This appeared to derive from:

• a willingness and ability to perceive and interpret different situations and develop meaning from them (Gibson, 1986) and in relation to them (Lave, 1993, 1996a)
• a sufficient understanding of different procedures to allow appropriate procedures to be drawn upon (Whitehead, 1962)
• a mathematical confidence and understanding that led students to adapt and change procedures to fit the demands of new situations.

The Amber Hill students were not given the opportunity to interpret different situations, to form knowledge in relation to different settings or to think about or reflect upon different procedures. They did not use mathematics within authentic activities or discuss mathematics in a social environment. All of these features seem to have been important to the Phoenix Park students and all of these features were present in Phoenix Park's project approach and completely absent in Amber Hill's textbook approach.

The results of this study lend support to some of the emerging ideas within the field of situated cognition. For example, the results have demonstrated the relational nature of learning and the interdependency of person, activity, knowledge and setting (Lave, 1993). The results have also shown that attempts to impart knowledge to students are less helpful than classroom environments in which students are enculturated and apprenticed into a system of knowing, thinking and doing. The perspectives of Lave have been instrumental to my analysis, but my ideas differ from those of Lave in a number of important ways. For example, whereas Lave uses a socially situated theory of learning to problematise the whole notion of schooling, I use it to problematise the way in which notions of learning are conceptualised within school. This difference derives from the fact that Lave does not consider learning to be 'a process of socially shared cognition that results in the end in the internalisation of knowledge by individuals, but as a process of becoming a member of a sustained community of practice' (Lave, 1993, p 65). Lave denies the existence of individual knowledge and so also refutes the idea that learning in one community of practice can help in any other (1993). The learning of the Amber Hill students supports this notion, because the students were unable to use their mathematics in situations outside of the classroom context, but the reflections of the Phoenix Park students appeared to contradict Lave's notion in two ways. First, the students talked about the way in which they used and adapted their knowledge and this knowledge appeared to be individual; second they gave indications that they used knowledge gained in the classroom within different communities of practice. Within Lave's perspective all learning is bound within and tied to the learning environment. I believe that learning is more powerful than this and that the results of this study demonstrate that certain forms of learning can transcend the boundaries of the learning environment. In the final analysis the distinction between my own and Lave's perspective is probably not important: she suggested (1996b) that the Phoenix Park students were able to use their knowledge in different situations because their classroom community of practice had extended outside of the classroom, I believe that the students had been enculturated into a way of thinking and working that accelerated their enculturation into new or different communities of practice. What is important is that the learning of the Phoenix Park students was qualitatively different from that of the Amber Hill students and the Phoenix Park students' classroom enculturation encouraged them to interpret and make sense of mathematical situations in a variety of different settings.

Chapter 9 Gender Based Inequalities: The Learner or the Pedagogy?

9.1 Introduction

> 'Perhaps we don't take seriously enough the voices that say again and again, 'but it doesn't make sense', and 'what's the point of it?' Perhaps what they are saying simply is true. Perhaps mathematics, their mathematics, secondary-school mathematics, doesn't make sense. Perhaps the fault is in the mathematics, and not the teaching, not the learning, not the people. At the very least it is a question worth focusing on for a while.' (Johnston, 1995 p 225)

Johnston presents an important idea in this extract that I intend to explore and develop in this chapter. As part of this analysis I shall critique theories that have focused the problem of female underachievement upon the responses of girls to mathematics teaching, rather than upon the sources of girls' disaffections. I shall also develop some ideas for an equitable form of mathematics teaching. In conclusion I shall suggest that the fault does indeed lie in the mathematics and not the girls, but that this does not relate to the nature of mathematics itself, but to the way in which it is conceptualised in school (Burton, 1995) and the pedagogic approaches that generally accompany it.

The underachievement and non-participation of girls in mathematics has become an established focus for concern over recent years. As a result of this many feminists, and others with equity concerns, have developed a range of initiatives which have been successful at raising girls' achievement, if not their continued participation. However, many of these initiatives have been overshadowed by a psychological paradigm that has attempted to explain the 'failure' of girls. Attribution theory (Ames, 1984; Ames, Ames & Felker, 1977) has focused upon the anxiety of girls and the tendency of girls to attribute their failure to their own perceived lack of ability. This has been used by psychologists and educationists to suggest ways in which girls should change, ways in which they should become less anxious, more confident, in essence, more masculine. Anyon (1981) has described a tendency toward 'blaming the victim' and this process is evident in much of the research based upon attribution theory and 'intervention strategies' (Mura, 1995, p159). In such research the responsibility for change is laid firmly at the feet of the girls. The reasons for their actions are ignored and potential problems with mathematical epistemology and pedagogy are not considered. Willis (1995) comments that some people:

'appeared to hold the rather complacent belief that the curriculum was not an issue, and that it was equally appropriate 'for all students' in both content and pedagogy or, to the extent that it might not be, it was inherent in the 'nature of the subject' and, therefore, unalterable. Some suggested that the problem might be mathematics anxiety, low self-esteem, or a lack of confidence, but had 'no idea' how this might arise — these characteristics were, it seems, a corollary to being born female' (Willis, 1995 p189).

There is now an increasing amount of literature that is critical of this position. In a number of recent publications by women writers and researchers the implicit attacks upon the attributions and motivations of girls, sustained in the literature for at least twenty years, are shown to be entirely insufficient as an explanation for the underachievement of girls. The focus has been reclaimed and mathematics educators are explaining the reasons for underachievement, not in terms of a deficit model for girls, but in terms of mathematics pedagogy, practice and the wider school system (Burton, 1995; Johnston, 1995; Mura, 1995; Willis, 1995). These writers have shown that the tendencies of girls to avoid or underachieve at mathematics were not at all 'maladaptive' (Dweck, 1986), nor were they indicative of some internal deficiencies of their own. Rather, the girls' responses were due to their rejection of a mathematics that made little sense to them, was often taught badly and that seemed to be largely irrelevant.

In the last ten years there has been a growing support for a new process based form of mathematics. Burton (1995) proposes that knowing in mathematics should be redefined in terms of: 'its person - and cultural / social-relatedness; the aesthetics of mathematical thinking it invokes; its nurturing of intuition and insight; its recognition and celebration of different approaches, particularly in styles of thinking; and the globality of its applications.' (Burton, 1995 pp 220 - 221). Rogers and Kaiser (1995) make similar claims and add that the developments that have been made to move school mathematics in this direction, have brought new insight into the underachievement and non-participation of women and girls. However, support for a process based form of mathematics has not only emanated from the feminist community. Official sources such as HMI (1985) and Cockroft (1982) in this country and the NCTM (1989) in the United States have also made proposals to further the use of open-ended work in order to improve the mathematical experiences of students. Where Burton differs from the more general reformists is in her claim that school mathematics, as a discipline, has been rendered masculine by a 'misguided stress which is laid on those very attributes of mathematics which are no longer acceptable to mathematicians, that is completeness, certainty and absolutism' (Burton, 1986a p 7).

The associations Burton draws between completeness, absolutism and masculinity are interesting, particularly because these themes or associations recur in various different guises within different strands of gender research. Gilligan (1982) and Becker (1995) relate the underachievement and non-participation of girls and women to their learning styles and ways of thinking and knowing. Gilligan describes 'separate' and 'connected' thinking (Gilligan, 1982 p35) and asserts that separate thinkers prefer to work with subjects that are characterised by logic, rigour, absolute truth and rationality. Connected thinkers, on the other hand, prefer to use intuition, creativity, personal processes and experience. Becker (1995) claims that separate thinkers tend to be boys and connected thinkers tend to be girls, again relating masculinity to hardness and completeness, femininity to relativism and experience. Head (1995) has suggested that girls also prefer co-operative, supportive working environments whereas boys work well in competitive, pressurised environments. These various claims about the gendered preferences of students are important to our understanding of difference in relation to achievement and participation. They also provide an important backdrop to the recent pedagogical and epistemological moves to bring school mathematics closer to an experiential, open and discursive discipline.

These ideas and developments seem important to consider in the light of the girls' and boys' responses to mathematics teaching at Amber Hill and Phoenix Park. This is because the Phoenix Park approach presented an open, discursive and experiential form of mathematics and the responses of girls to this, and the traditional approach of Amber Hill, inform the new theoretical positions proposed. The perspectives of the students at Amber Hill and Phoenix Park are also made important by the fact that there is very little research available to support the claims made about the potential of process based mathematical environments, mainly because of the scarcity of these environments in schools. The presence of gender based responses at the two schools also forms an important part of the overall picture of mathematics teaching and learning at Amber Hill and Phoenix Park school.

9.2 Amber Hill School

Throughout my research study many of the girls *and* boys at Amber Hill expressed strong preferences for their coursework lessons and spoke vividly about their dislike of textbook lessons. However, the reasons the girls and boys gave for their preferences and, importantly, the responses of the students to the textbook approach they disliked were qualitatively different. This difference was intricate and complex but for the girls it involved what I would call a 'quest for understanding', for the boys it involved playing the 'school mathematics game'. I will attempt to illustrate and illuminate these propositions now.

9.2.1 The quest for understanding

All of the Amber Hill girls interviewed in years 10 and 11 expressed a strong preference for their coursework lessons and for the individualised booklet approach which they followed in years 7 and 8, as against their textbook work. The girls gave very clear reasons why these two approaches were more appropriate ways of learning mathematics for them; all of these reasons were linked to their desire to understand mathematics. In conversations and interviews students expressed a concern for their lack of understanding of the mathematics they encountered in class. This was particularly acute for the girls, not because they understood less than the boys, but because they appeared to be less willing to relinquish their desire for understanding and play the 'school mathematics game':

> J: He'll write it on the board and you end up thinking, well how comes this and this?, how did you get that answer? why did you do that?, but...
> M: You don't really know because he's gone through it on the board so fast and...
> J: Because he understands it he thinks we all do and we don't. (Jane and Mary, AH, year 11, set 1)

These students show that they were interested in meaning and understanding, they did not just want to learn work, they wanted to know 'how comes this and this?, how did you get that answer?'. Many of the boys did not like their textbook lessons and they did not understand any more of the work than the girls, but they seemed to have formed different goals to the girls. These related to speed and the attainment of correct answers, rather than understanding. Thus, typically:

> A: I don't mind working out of textbooks, because you can get ahead of everyone else. (Alan, AH, year 11, set 3)

> J: I dunno, the only maths lessons you like are when you've really done a lot of work and you're proud of yourself because you've done so much work, you're so much ahead of everyone else. (James, AH, year 10, set 2)

Both of these boys emphasised the importance of *relative* performance (Head, 1995), rather than absolute learning. The goals and expectations of many of the boys related to working quickly and completing lots of questions. These were not particularly beneficial goals, in the long term, for the boys came to regard mathematics learning as a system of rule following and rote learning. They received rewards for correct answers and this was all that they cared about. However, as a coping strategy, the boys' response was more productive in accommodating to the demands of the school system. Many of the girls were very concerned about understanding their mathematics and because they felt they were unable to do so, they would often become anxious and fall behind.

> J: When I understand there's no stopping me, you saw me with that, when we had that equation sheet and the end of the lesson came and I was - do we have to go? I just want to finish this - once I understand something I'm alright, but it kind of frustrates me if I'm sitting there for an hour and I don't know exactly what I'm doing. (Jane, AH, year 11, set 1)

> M: The only work I like is when I understand what I'm doing, it's when I don't understand and I get confused, that's when I don't like it much. (Mary, AH, year 11, set 1)

As a result of a number of different data sources I became convinced that it was this desire to understand, rather than any difference in understanding, that really differentiated the girls from the boys. The girls knew that they needed to understand mathematics, but they felt that they had no access to understanding within their fast, pressured, textbook system.

> S: I just try and do it now, I don't know what it means, I just try and work fast. (Sara, AH, year 10, set 3)

The girls' preference for a different approach undoubtedly increased their disaffection in response to mathematics, but the conflict they experienced was heightened by their awareness of the mismatch between their desire for understanding and their classroom experiences:

> JB: Is maths more about understanding work or remembering it?
> J: More understanding, if you understand it you're bound to remember it.
> L: Yeah, but the way Mr Langdon teaches, it's like he just wants us to remember it, when you don't really understand things. (Louise and Jackie, AH, year 10, set 1)

Further evidence of the different priorities held by the girls and boys at Amber Hill came from questionnaires. In their year 10 questionnaire I asked the students to rank five different areas of mathematics in terms of their importance. These were: getting a lot of work done, working at a fast pace, understanding, remembering rules and methods and knowing how to use a calculator. Three of these categories produced significant differences between girls and boys at Amber Hill:

• 91% of girls regarded understanding as the most important aspect of learning mathematics, compared with 65% of boys (χ^2 = 16.96, 4 d.f. $p < 0.001$).
• 4% of girls regarded remembering rules and methods as the most important, compared with 24% of boys ($p = 0.001$, Fisher's exact test).
• 5% of girls regarded getting a lot of work done as the most or second most important aspect of learning mathematics, compared with 19% of boys ($p = 0.016$, Fisher's exact test).

The differential responses of girls and boys were also evident in lessons. During my lesson observations I would frequently observe boys racing through their textbook questions, trying to work as quickly as possible and complete as many questions as they could. I would, just as frequently, observe girls looking lost and confused, struggling to understand their work or giving up all together. In lessons I would often ask students to explain what they were doing to me. The vast majority of the time the students would tell me the chapter title and, if I asked them questions like 'yes but what are you actually *doing*?' they would tell me the number in the exercise; neither girls nor boys would be able to tell me why they were using methods or what they meant. On the whole the boys seemed unconcerned, or less concerned, by this, as long as they were getting their questions right. The girls would get questions right, but they wanted more:

> M: It's like, you have to work it out and you get the right answers but you don't know what you did, you don't know how you got them, you know? (Marsha, AH, year 10, set 4)

Marsha, like Jane and Mary earlier, demonstrates a desire for understanding and meaning which extends beyond the acquisition of 'right answers'. In my depiction of the students' experiences at Amber Hill I have concentrated, so far, upon the differences between the girls' and boys' reactions to their textbook lessons. But the girls at Amber Hill were more than just critical of their school's methods. In interviews the girls offered extremely clear descriptions of positive learning experiences and the depth of their analyses of different classroom approaches was extremely impressive. All of the positive experiences which the girls relayed took place during coursework lessons or individualised booklet lessons. The reason that the girls liked these approaches was because of the freedom they experienced to either: use their own ideas, work as a group or work at their own pace. All of these practices, the girls claimed, gave them access to a depth of understanding that textbook work denied them.

a) Using their own ideas

In chapter 6 I described the preferences the students had for open ended work. This was generally because the students did not believe that their textbook lessons allowed them to use their own ideas, think creatively or use their initiative. Preferences for these features of their learning were more prevalent amongst girls than boys. This was shown by some of the year 11 questionnaire responses that prompted significant differences between girls and boys. Significantly more boys agreed with the following:

- It is important in maths to answer questions the way the teacher wants you to, girls = 49%, boys = 70% ($\chi^2 = 5.69$, d.f. = 1, $p < 0.02$)

Whereas significantly more girls agreed with the statements:

- It is important in maths to find your own way of solving problems, girls = 84%, boys = 66% ($\chi^2 = 5.14$, d.f. = 1, $p < 0.05$).
- It is important in maths to think about different types of maths, girls = 87%, boys = 71% ($\chi^2 = 4.72$, d.f. = 1, $p < 0.05$).

The boys at Amber Hill reported enjoying their open-ended coursework, but they were less convinced of the value of having to think for themselves and the need to put effort into their work, mainly because this conflicted with their desire for speed and correct answers:

> G: I don't really like investigations.
> JB: Why not?
> G: It's hard.
> JB: How are they different to what you do normally?
> G: Because in chapters, the teacher explains how to do it, but with the investigations you have to do it by yourself.
> JB: Is that more difficult?
> G: Yeah, 'cause in the chapters, once you know how to do it, you're away. (Gary, AH, year 11, set 3)

Although many of the boys reported enjoying their coursework, this would generally be because it was a change, few of the boys talked about the opportunity to think or to use their initiative, or the access it gave them to understanding, whereas this was central to the reasoning of the girls.

b) Group work

The girls also expressed preferences for working co-operatively in groups, which they were allowed to do during their coursework projects:

> JB: OK What about the coursework, what did you think of that?
> L: I liked that.
> S: Yeah I liked that.
> L: It was good - but we done it together.
> S: We worked together.
> L: Yeah and we done good on all of them - I got about eight and a half on the last one, out of ten which is really good - but that was because we was working at our own pace, again, because it's an open ended task. (Sara & Lola, AH, year 11, set 3)

One of the girls, who had recently transferred from another school, described the way that her previous teacher had used SMP books in an effective way by encouraging the class to work collectively and discuss their work:

> P: It was a lot better in my old school when we had this teacher and we had them books, but he did it in a different way, it was much better, we had a few questions to do, then he'd help us and then we'd all discuss it and how to do it and it was more interesting. (Paula, AH, year 10, set 2)

The girls related the advantages of group work to the access it gave them to understanding. The boys rarely mentioned their experiences of group work and those that did varied in their responses to it. Some of the boys disliked working in groups because they felt that it slowed them down:

> L: Well, it could have been useful, but you could do it in half the time yourself, like you speed along, you understand it, next topic. But it slows you down, the rest of the class. (Leigh, AH, year 10, set 2)

The different responses of the girls and boys, in relation to group work, again related to the opportunity it gave them to think about topics in depth and to increase their understanding through discussion. This was not perceived as a great advantage to the boys, probably because the aim, for many of the boys, was not to understand, but to get through work quickly.

c) Working at their own pace

In chapter 6 I showed that an overwhelming desire for both girls and boys at Amber Hill was to work at their own pace. This desire united the sexes, but the underlying reasons for this divided them. The boys enjoyed individualised work that could be completed at their own pace because it allowed them to tear ahead and complete as many books as possible:

> C: It was better then weren't it?
> M: Yes.
> C: We used to compete.
> M: Yeah, we could do it at our own pace.
> C: Yeah, we could do it at our own pace and we used to be books ahead of the others.
> (Chris and Marco, AH, year 11, set 4)

> A: Before, when we had the little books, they were only short pages and we used to like compete with each other, see who'd done the most, who'd got the most percentage and that was like, most interesting. (Alan, AH, year 11, set 3)

The girls wanted to work at their own pace so that they could understand what they were doing, before they moved onto something else:

> L: We had time to read it didn't we? We had time to read it through and if we didn't get it we had time to read it again, but like with this, we can only read it through once because she wants us to hurry up and get on and finish it. (Lindsey, AH, year 11, set 4)

The girls, again, explained their preference for working at their own pace, in terms of an increased access to understanding. The boys' preferences related to the creation of a competitive working environment. This difference was reflected in a year 11 questionnaire item which produced a significant difference between girls and boys:

• It is important in maths to get more things right than other people, 13% of girls and 29% of boys agreed ($\chi^2 = 4.72$, d.f. = 1, $p < 0.05$)

The girls consistently demonstrated that they believed in the importance of an open, reflective style of learning and that they did not value a competitive approach or an approach in which there was one teacher determined answer. Unfortunately for them the approach that they thought would enhance their understanding was not attainable in their mathematics classrooms, except for two weeks of each year.

9.2.2 Top set girls

In chapter 4 I described the speed and pressure which were an important part of the set 1 experience at Amber Hill. Many of the students reported that these features of their set 1 lessons had a negative effect upon their learning and this effect seemed to be particularly detrimental for the girls. In the top set group in my case study cohort (n = 33) I identified 15 students who were underachieving. This identification derived from a comparison of their NFER scores for mathematics on entry to the school and their success in years 7 and 8 when they used SMP booklets with: their relative positions in the set 1 group, my assessment exercises, their GCSE grades and the opinion of their teacher. Eleven of the 15 students were girls, which represented over two-thirds of the girls in the group. In the short context questions given to students at the beginning of year 9 and again at the end of year 10, 9 of these 15 students attained *lower* grades in year 10 than in year 9, whereas the rest of the top set improved their grades or stayed at the same level. Most of the 15 students were easy to locate in lessons. Six of the girls sat together and looked lost, confused and unhappy in lessons and completed hardly any work. Some of these girls were, at one time, the highest mathematical attainers in the school. On entry to the school Carly attained the highest NFER entry mark in the school and Lorna attained the second highest mark, both of these girls attained the *lowest* GCSE grade in set 1, grade E. In the year 10 questionnaires, when students were asked to describe lessons, Carly and Lorna gave the following descriptions:

> Carly: Not interesting. You go through the work too quickly and things don't get explained properly.
>
> Lorna: The teacher stands by the blackboard for half the lesson explaining the work and everyone seems confused and not understanding the work. It goes too fast and it is very uninteresting.

In the top set there were 16 girls and 17 boys. In GCSE examinations there were statistically significant differences between the achievement of the girls and boys in set 1, even amongst such a small number of students. In the GCSE examinations boys attained 14 of the 19 A-C grades from set 1; girls attained 11 of the 14 D and E grades ($\chi^2 = 8.8$, d.f. = 1, $p < 0.01$). Gender differences in achievement were most marked amongst the highest attaining students in the school, which is consistent with national patterns of mathematics performance. Studies of GCSE grades in the UK have shown that, between 1988 and 1991, the number of girls attaining GCSE grades A - C went up by 10%, which narrowed the gap between girls and boys considerably (Elwood, Hayden, Mason, Stobart, & White, 1992). In 1991 only 3% more boys attained grades A - C than girls. However, sex differences in mathematical attainment at GCSE remain amongst the highest ability students (Askew & Wiliam, 1995). In 1993 there were five boys to every four girls who attained a GCSE grade A when girls were, generally attaining higher grades than boys in other subjects. In the national curriculum key stage 3 mathematics tests, taken by students at age 14, the only gender differences in favour of boys, recorded in 1993 and 1994, were amongst the top 5% of students. The highest level was attained by three boys to every two girls. Such differences, although they affect a small proportion of girls, are extremely important because these high attaining girls, who could and should be getting grade A's, are the students who could be future role models, such as mathematicians, engineers and teachers of mathematics. The girls are also being denied access to a subject that they could excel at:

> C: When we first came to this school I had always had really high marks for maths, now I've just gone downhill.
> JB: Do you know why that is?
> C: I feel rushed, some areas, I don't understand, he just rushes through and I still don't understand it. (Carly, AH, year 11, set 1)

The experiences and attitudes of the high 'ability' girls in the top set at Amber Hill give some indication of the possible reasons for the gender imbalance reported at the highest levels in mathematics. These may be linked to intrinsic features of top set environments, particularly intense pressure and fast paced lessons. Further evidence for this suggestion is provided by the work of Dweck (1986). Through a review of different research studies from the social-cognitive framework, Dweck has shown that 'maladaptive' motivational patterns affect motivation and influence the quality of performance. She has also shown that tendencies toward unduly low expectancies, challenge avoidance, ability attributions for failure and debilitation under failure have been especially noted in girls and particularly 'bright' girls.

Dweck asserts that one of the characteristics of 'maladaptive' motivational patterns is a tendency to seek situations which will lead to good performance, rather than situations which will involve challenge and in which students may learn. But I would question whether such tendencies can really be described as 'maladaptive' in many of the mathematics classrooms in which the girls are learning. In classrooms such as Amber Hill, students are rewarded for the number of correct answers they get, not for the acquisition of understanding. In such classrooms it seems unreasonable to expect students to seek difficult and demanding situations which may not lead to correct answers, particularly when correct answers, in a mathematics classroom, have always been the only route to success. Dweck's suggestion that bright girls underachieve because of *maladaptive* tendencies may be seen as an example of blaming the victim (Anyon, 1981). One result of this could be that the blame is removed from the school system and focused upon the reported inadequacies of girls. But the tendency to avoid situations which result in failure, taken in the context of high pressure mathematics classrooms (such as top sets) is not at all maladaptive, in many ways it is eminently sensible. High pressure environments which expose students when they do not attain correct answers (Buxton, 1981) cannot foster a desire in students to seek challenging situations in which they may not succeed:

> JB: Can you describe a maths lesson which you haven't enjoyed?
> L: Where he was doing something about perimeters of circles and radiuses and that and he picked me out, because I didn't look interested and he was telling me all these things and I had to work it out and I just sat there, I didn't know anything, 'cause I didn't think he explained it and he made me look a fool in front of the whole class, yeh, 'cause I just couldn't speak, 'cause I didn't know what he was talking about and he goes "see me after the lesson". (Louise, AH, year 10, set 1)

The sort of high pressure environments generated within many mathematics top sets probably encourage and re-enforce the tendencies Dweck notes amongst bright girls. It also seems reasonable that girls should become anxious (Tobias, 1978) in response to these environments, rather than reposition their goals and replace their desire for understanding with a desire for speed:

> P: Some of the stuff you do, it's just hard and some of it's really easy and you can just remember it every time, I mean sometimes you try and race past the hard bits and get it mostly wrong, to go onto the easy bits that you like. (Paul, AH, year 10, set 1)

Im the UK there is evidence that mathematics is taught to setted groups in the vast majority of schools (OFSTED, 1996 reported in *The Guardian* 8/6/96). I would suggest that the negative attitudes reported amongst bright girls (Dweck, 1986) and the inequities present amongst the top 5% of students (Askew & Wiliam, 1995) may derive from some of the intrinsic features of top set mathematics classrooms, rather than the personal inadequacies of girls. At Amber Hill the top set girls were clear about the reasons for their disaffection and underachievement and these did not relate to their own shortcomings but to the way in which mathematics was presented to them within their fast and pressured top set classrooms.

9.2.3 Amber Hill summary

The girls at Amber Hill experienced a real conflict. They believed in the value of understanding and they knew that there was a need to think about work, but their school's approach did not allow them to do so. When they worked at their own pace, when they worked in groups and when they worked on open-ended projects they felt able to gain access to understanding. Hence their preference for these approaches. The majority of the boys at Amber Hill also preferred a more open, reflective approach, but in the absence of this they seemed able to adapt to a system that they did not like, but which gave them high marks. The boys were not happy, but they were able to play the game, to abandon their desire for understanding and to race through questions at a high speed. Dweck (1986) has talked about the importance of students' goals to their subsequent success and failure in cognitive performance. It was clear that the goals that the Amber Hill girls formed were almost impossible to achieve in their mathematics lessons and the effect of this conflict upon their regard for mathematics was also clear.

9.3 Phoenix Park School

The students at Phoenix Park worked co-operatively on projects at all times; they were given the freedom to work in any way that they wanted; they were encouraged to think for themselves; they discussed ideas with each other and they worked at their own pace. In these respects, the approach at Phoenix Park matched the idealised learning environment represented by the girls at Amber Hill. Not surprisingly perhaps, gender differences were evident amongst the students at Phoenix Park and these worked in favour of the girls. However, these affected a relatively small number of students and they did not result in widespread disaffection and underachievement.

In chapter 6 I described a group of students, who were mainly boys, who resisted the approach of Phoenix Park. These students related their low motivation to the open approach and as they, and some of the girls reported in chapter 6, they wanted more structure in their work, they wanted someone to tell them what to do 'they didn't want to find things out for themselves' (Anna, Phoenix Park year 11). The fact that this response was concentrated amongst a small group of boys suggests that it was gender based. Martin Collins, the mathematics co-ordinator at Phoenix Park, believed that some of the boys lacked the maturity to take responsibility for their own learning and there was some evidence that this was true. For example, in year 10 interviews some of the boys were extremely antagonistic towards the approach, but by the end of year 11 they were considerably more positive. This probably related to the fact that they needed time to get used to the demands of an open approach, as well as the increase in the students' maturity in year 11.

The boys that appeared to be disaffected because of the approach at Phoenix Park were in the minority and they demonstrated similar low motivation and bad behaviour in all of their lessons (although most, but not all, of these were project based). Thus, the gender based responses at Phoenix Park were very different from those at Amber Hill. At Amber Hill they were more consistent and widespread and they affected girls who were both successful and motivated in other subject lessons. Also, the girls and boys at Phoenix Park did not develop different perceptions about mathematics. In section 9.2 of this chapter I showed a year 10 questionnaire item in which students were asked to rank 5 different aspects of mathematics in terms of importance. This produced significant gender differences on 3 of the 5 mathematical features at Amber Hill and no significant differences at Phoenix Park. In section 9.2 I also showed that there were significant differences in the responses of Amber Hill girls and boys to 4 statements in their year 11 questionnaire describing different aspects of mathematics. There were no significant differences between the girls and boys on any of these questions at Phoenix Park. This is important because at Amber Hill the girls seemed to value aspects of mathematics teaching and learning which were not present in their school's approach. At Phoenix Park the views of girls and boys were consistent with the approach they encountered at school.

Further indications of the gender patterns at the two schools were provided by the year 9 questionnaire. Two of the questions asked students whether they were good at mathematics in school and whether they enjoyed school mathematics. In both of these questions, boys gave more positive responses than girls at Amber Hill and girls gave more positive responses than boys at Phoenix Park.

Table 9.1 Do you think you are good, OK or bad at the maths you do in school?

		%'s good	OK	bad	n
AH*	g	6	80	13	82
	b	32	66	1	77
PP ‡	g	23	72	5	43
	b	22	65	13	60

* $\chi^2 = 18.04$, d.f. = 2, $p < 0.001$

‡ $\chi^2 = 0.04$, d.f. = 2, $p < 0.98$

[N.B. some of the cells contain values that are smaller than 6]

Table 9.2 Do you enjoy the maths you do in school?

		%'s always / most of the time	sometimes	hardly ever / never	n
AH*	g	37	52	11	82
	b	51	44	5	77
PP ‡	g	63	23	14	43
	b	45	35	20	60

* $\chi^2 = 7.72$, d.f. = 2, $p < 0.05$ [N.B. 1 cell contains a number less than 6]

‡ $\chi^2 = 3.18$, d.f. = 2, $p < 0.30$

These two questions demonstrate the same pattern. At Amber Hill, where students followed a traditional, textbook approach, the boys gave more confident responses and reported enjoying mathematics more than the girls. At Phoenix Park, where school mathematics was open, experiential and discussion oriented, the reverse was true, girls gave more positive responses than boys but the differences between girls and boys were not significant. The results concerning enjoyment and understanding reported in these year 9 questionnaires were repeated in years 10 and 11.

In their year 9 questionnaire the students were also asked to write sentences about the aspects of lessons they liked, disliked and would like changed. In response to these three questions there were a total of 88 comments from Amber Hill students about their perceived lack of understanding (see appendix 7). The majority of these comments reflected a considerable amount of anxiety and more than two-thirds of the comments were given by girls. At Phoenix Park, there were 6 comments in response to these three questions that reflected anxiety about understanding, and these came from equal numbers of girls and boys.

In interviews the Phoenix Park girls also gave very different responses to the Amber Hill girls. Many more of the Phoenix Park girls reported enjoying mathematics, and this they related to the fact that they worked in open, non-competitive environments in which they could use their own ideas and think deeply about their work.

In GCSE examinations there were significant disparities in the achievements of Amber Hill girls and boys with 20% of the boys and 9% of the girls attaining GCSE grades A to C ($\chi^2 = 3.89$, d.f = 1, $p < 0.05$). At Phoenix Park there were no significant differences in the achievements of girls and boys with 13% of the boys and 15% of the girls attaining grades A-C. The relatively low proportion of Phoenix Park boys attaining grades A-C, compared with Amber Hill boys could be taken as an indication that the Phoenix Park approach disadvantaged boys. However, other forms of evidence do not support this view. It seems more likely that the disparity between Phoenix Park's open approach and the GCSE examination, discussed in chapter 8, diminished the proportion of both girls and boys attaining A-C grades in the examination.

9.4 Attribution Theory

For a number of years psychologists and educationists have attributed the underachievement of girls to mathematical anxiety and lack of confidence. A number of studies which have documented girls' anxiety have led onto the development of intervention programmes designed to make girls more confident. Amazingly, these studies have not considered the reasons for girls' anxiety. Rather, the girls' reactions have been considered unfortunate, or even 'maladaptive' (Dweck, 1986). One of my aims in this chapter has been to identify the reasons for the girls' adverse reactions to school mathematics and to give voice to their concerns. The girls at Amber Hill talked openly about their mathematical anxiety, but they did not attribute this anxiety to any deficiencies of their own. They were quite clear about the reason for their anxiety which was the system of school mathematics that they had experienced.

> H: If we don't understand it, he'll shout at us, call us idiots in other words, but it's his own teaching. (Helen, AH, year 11, set 1)

M: Every report he writes, he writes good ability but lacks confidence, but I know that I can do the work - in a different situation, with a different sort of work. (Maria, AH, year 11, set 1)

Here the students clearly attribute their 'underachievement' to the mathematical pedagogy and epistemology they experienced. Other students said that they had made some positive achievements in mathematics in spite of, rather than because of, their mathematics teaching:

J: I hate it (laughs) literally, I know it's useful and we need it, I know that, but I'm not that bad at it, I usually come about in the middle section of the group, but it's one lesson I really can't stand.
JB: Really?
J: I'm sorry to say this but yes - I haven't really picked up maths at all.
JB: But you're good at it aren't you?
J: Well I'm doing OK but that's just because it's in my nature.
M: We have a go. (Jane and Mary, AH, year 11 set 1)

The girls were also clear that their anxiety did not relate to the nature of mathematics as a subject, but to the *type* of school mathematics they had experienced.

JB Why were you doing so much better before do you think?
C Well in maths, in my junior school it was quite enjoyable, because it was like all different all the time and I understood it, we used to do a bit of everything, now maths is all the same, it's boring and tedious. (Carly, AH, year 11, set 1)

S: Before I came to this school, I was really good at maths, but since I've come here I've got a lot worse.
A: Yeah me too, I'm no good at maths now.
JB: Why is that?
S: Well, 'cause I'm no good.
JB: You're no good?
S: No, well, I could do the maths, but not like this. (Suzy and Anna, AH, year 11, set 2)

Many of the girls believed that they were mathematical failures and many demonstrated anxiety in lessons. But none of the girls related this to their own perceived inadequacies. They felt that they had been disadvantaged by their school's mathematics teaching and 'in a different situation, with a different sort of work' they could have done well.

9.5 Discussion and Conclusion

In concluding this chapter I would like to draw together a number of points which, I feel, illuminate or contradict existing theoretical standpoints consistently deployed within education and psychology, relating to girls and mathematics.

1) At Amber Hill school a large proportion of girls became disaffected by, and disillusioned with, their school mathematics. These girls achieved less than a similar cohort of girls at Phoenix Park and were considerably more disaffected. The girls at Amber Hill were eloquent about the reasons for their disaffection and under-achievement and these they related to pace, pressure, closed approaches which did not allow them to think and a competitive environment. Conversely, they related open work, discussion and co-operation to understanding. Burton (1986a, 1986b, 1995) has proposed that process-based mathematical approaches will raise the achievement, and enjoyment, of girls but, to date, there has been little research evidence to support this.

2) The difference between the achievement of girls and boys at Amber Hill in relation to a traditional, closed approach appeared to relate to their *adaptability* to an approach they disliked. Both sets of students expressed preferences for open, discussion-oriented work but boys adapted to the converse of this, whereas the girls, generally, did not. The boys tended to rush through questions in order to achieve speed, if not understanding. The girls would not do this, they seemed unable to suppress their desire for understanding and continued to strive towards it - which probably worked to their disadvantage.

3) Attribution theory has played an important part within psychological analyses of girls' underachievement in mathematics. Various psychologists have suggested that girls tend to attribute their lack of success to themselves and Dweck (1986) proposes that this leads to a condition known as 'learned helplessness'. Attribution theorists have tended to rely upon experimental evidence to support their claims and it is interesting to contrast this evidence with the reported experiences of girls in *real*, classroom situations. For at the end of five years of secondary schooling the girls at Amber Hill were clear about the reasons for their lack of success in mathematics and these had nothing to do with their own inadequacies. Psychologists have claimed that girls often believe that their 'locus of control' lies within themselves. This leads to their becoming 'overwhelmed by a sense of guilt and the demands they make on themselves' (Head, 1995, p10) which often stops them from being able to improve their situations. The Amber Hill girls found that they were unable to improve their situation, not because they were disillusioned by their own

inadequacies, but because they were powerless to change the epistemological and pedagogical traditions of their institution.

4) Dweck (1986) has analysed the negative reactions of girls to school mathematics and described their responses as 'maladaptive' (1986, p1040). I have argued that the girls' responses should be considered in relation to their goals in mathematics and if their goals relate to understanding, which they clearly do, their responses are far from maladaptive. I believe that the work of intervention strategists may have, unwittingly, served to prolong a period, from which we are only now emerging, in which girls explanations for their own under achievement have been ignored. Burton also argued in 1986 that intervention strategies would be ineffective if they did not attempt to locate and understand the nature of girls' 'problems' from a broad perspective (Burton, 1986b). Very few researchers consulted the girls, or listened to their concerns, before labelling them as 'anxious' and sending them on programmes to become more confident. But it is clear to me that the girls' responses to school mathematics make perfect sense, indeed, their proposals for the improvement of school mathematics are markedly similar to those offered by experienced mathematics educators. They want to be able to understand mathematics and they won't accept a system which encourages rote learning of methods and procedures that mean little or nothing to them.

5) Previous research which has considered the links between sex and learning styles has reported small or negligible effect sizes. This has led educationists to dismiss any possible differences between girls and boys, partly because it would be dangerous to form expectations on the basis of *presumed* learning styles (Adey, Fairbrother, Johnson & Jones, 1995). However, it seems equally dangerous to ignore sex-based preferences for styles of learning when the teaching approaches that are offered to school students are clearly biased towards one group of students. Mathematics, as it is currently and widely taught, is not equally accessible to girls and boys and this appears to relate to preferences of pedagogy. Many of the psychological studies that have reported negligible learning style differences between girls and boys (see for example Riding & Douglas, 1993) have done so by reducing learning preferences to small measurable concepts related, for example, to a verbal versus imagery approach or a holist versus analyst approach. These are then assessed through closed questionnaires, administered in experimental settings. One of the indications of this research study was that the preferences of girls for open, reflective and discursive approaches would not be easily identifiable through experimental tests for learning styles. The preferences of the students at Amber Hill were wider ranging, more complex and, importantly, related to the context of their mathematics lessons. These preferences may well have been 'situation specific' (Lave, 1988) which would have seriously limited their testability in experimental settings.

6) The disparity between preferred modes of working and school mathematics practice was most acute for the highest ability girls at Amber Hill. In recent years girls' performance in mathematics has improved dramatically, in relation to boys (Elwood, Hayden, Mason, Stobart, & White, 1992) and the only real differences that still exist in favour of boys occur amongst the top 5% of students. The disaffection and under achievement which was common amongst the highest ability girls at Amber Hill derived partly from the increased pressure and speed associated with top set environments as well as the increased *awareness* of the girls of the inadequacy of an approach that denied them access to understanding. These girls, more than others, wanted to understand their mathematics and, consequently, these girls, more than others become anxious and under achieved when they were denied the opportunity to do so.

I began this chapter with a quote from Johnston (1995) which suggested that it may be time to listen to the girls who complain about the nature of school mathematics. I have attempted, in this chapter, to show the importance of giving voice to girls' concerns, because what they are saying appears to make a lot of sense. However, it is important not to lay the blame for their disaffection upon mathematics *per se*, for the fault lies not with the intrinsic nature of mathematics, but with school mathematics as it is commonly constructed. Rogers and Kaisers' (1995) talk about the need to move away from a paradigm that has blamed girls for the pedagogical and institutional inadequacies of the school system and move towards a new form of school mathematics. At Phoenix Park the teachers were quite radical in their reconstruction of school mathematics and this seemed to produce an alleviation, or even eradication, of mathematical anxiety and under achievement for girls. Importantly, they achieved this by changing the mathematics pedagogy and epistemology, not the girls.

Chapter 10 Setting, Social Class and Survival of the Quickest

10.1 Introduction

The appropriateness of setting, streaming and mixed ability grouping remains a contentious and widely disputed issue within education. This is made more interesting by the fact that notions of student grouping interplay uniquely with the changing politics of education and the fluctuating influence of research over policy. In the UK moves from streaming to setting to mixed ability teaching and back again to setting can be related directly to developments in research, educational theory and the political agenda of the time. In this chapter I will present a brief overview of the theoretical and historical developments which surround student grouping, I will then aim to consider the influence of grouping upon the perceptions and understandings the students developed at Amber Hill and Phoenix Park.

In the nineteen-fifties almost all of the schools in the UK were streamed and students were differentiated within, as well as between, schools. Jackson (1964) conducted a survey of junior schools and found that 96% were streamed and 74% of the schools had placed children into ability groups by the time they were seven years old. Jackson's study also identified some of the negative effects of streaming, including the tendency of teachers to under-estimate the potential of working class children, and the tendency for low-stream groups to be given less experienced and less qualified teachers. This report contributed towards an increasing public awareness of the inadequacies of streamed systems. In 1967 the Plowden report recommended the abolition of all forms of ability grouping in primary schools (Bourne & Moon, 1994).

The nineteen-seventies and early eighties witnessed a growing support for mixed ability teaching in the UK. Studies by Hargreaves (1967) and Lacey (1970) both explored and highlighted the ways in which setting and streaming created and maintained inequalities, particularly for working class students. Ball (1981) also conducted a highly influential study of a school moving from setting to mixed ability teaching that served to establish the link between setting and working-class under achievement. Schools appeared to be receptive to the results of these research studies, which fitted with the more pervasive concern for educational equality at that time.

The nineteen-nineties have witnessed an apparent reversal of this thinking, manifested by large numbers of schools returning to policies of setting. Even within the current political climate such a move must be considered to be remarkable, given that setting was replaced in many schools, less than thirty years ago, because of concerns about issues of equity and disadvantage. Yet the motives behind such moves are easy to locate. As a result of the 1988 Education Reform Act, schools in the UK have been forced to adopt a highly structured and differentiated national curriculum (Dowling & Noss, 1990), a curriculum that many teachers believe is incompatible with mixed ability teaching. At the same time schools are now having to spend time, money and energy creating images that will attract the 'right' sort of parents - parents whose children will gain high GCSE grades and secure their school's survival in the newly created educational marketplace (Gewirtz, Ball, & Bowe, 1993). Both of these developments have meant that setting is now back in vogue and schools are returning to policies of differentiation and polarisation (Abraham, 1994) in alarming numbers:

> 'Mixed ability is also on our agenda. We're reviewing it at the moment. (...) The National Curriculum has made us review it really. I think it may well have an offshoot though, it may make us attractive to parents... The staff are finding it more and more difficult, you see, resources have been cut, there's no doubt about it. With the National Curriculum coming in there are more and more subjects which are saying, coping with that ability range within the classroom, without the kind of support you need is very difficult.' (Head teacher) (Gewirtz, Ball & Bowe, 1993 p 243)

It seems that many schools have accepted, or at least come to terms with the fact, that students must be labelled as low attainers, even if this means that their future roles are defined for them at the onset of their secondary schooling (Rosenthal & Jacobson, 1968; Rosenthal, 1974). They even seem to have accepted the nature of a process that seems to select as much by class, race and gender than ability:

> 'Although ability is supposedly the major criterion for placement in subject and examination levels, ability is an ambiguous concept and school conceptions of ability can be affected by perceptions that pupils are members of particular social or ethnic groups and by the behaviour of individual pupils. Factors related to class, gender, ethnicity, and behaviour can be shown to affect the placement of pupils at option time, even those of similar ability.' (Tomlinson, 1987 p106)

The fact that schools are prepared to accept, or ignore, the limitations of setting can probably be linked to a notion, held by many people across the education community, that setting raises academic achievement, at least for some students. At its worst setting is believed to enhance the experiences of students in high sets and diminish the experiences of students in low sets. Top-set students are assumed, implicitly or explicitly in much of the literature, to be in some way advantaged by their setting experience:

> 'Proponents of homogeneity (...) claim separation can improve fulfilment of personal potential — undoubtedly among the brighter students, but also among the weaker ones' (Dar & Resh, 1986 p 3).

These 'undoubted' beliefs about the advantages of setting for 'brighter students' may have served to stultify research into their credibility and perpetuate a notion that may not fit easily with the experiences of top set students. Research into the effects of setting and streaming in the UK and 'tracking' in the USA has been polarised by virtue of its concerns, its methodology and its geography. Research in the UK has concentrated, almost exclusively, upon the inequities of the setting or streaming system for those students who are allocated to low sets or streams. These are predominantly students who are also disadvantaged by the school system because of their race, class or gender (Hargreaves, 1967; Lacey, 1970; Ball, 1981; Abraham, 1995). These research studies have used mainly qualitative, case-study accounts of the experiences of students in high and low sets and streams to illustrate the ways in which curricular differentiation results in the polarisation of students into 'pro' and 'anti'-school factions. Such studies, by virtue of their value-based concerns about inequality (Abraham, 1994), have paid relatively little attention to the effects of setting or streaming upon the students' development of subject understandings. In the US, on the other hand, there have been a wealth of research studies that have compared the average scores of students taught in homogeneous and heterogeneous groups (Slavin, 1990). However, these studies have tended to compare average group scores rather than consider the responses of individual students to setting. The quantitative nature of these studies has also meant that they have not considered the way in which setting influences achievement or the processes by which it takes effect.

In this chapter I hope to bridge this gap by using qualitative and quantitative methods to consider the responses of individuals who were taught in low and high sets and mixed ability groups, as well as the overall achievements of students who were taught using the two approaches. I hope, in this way, to inform theoretical perspectives and to complete the picture of the many influences on students' learning at Amber Hill and Phoenix Park.

10.2 The Setting Experience

The Amber Hill mathematics department was an interesting place to consider the impact of setting, because the students experienced both mixed ability and setted approaches within the same school for mathematics, at different times. In year 7 the students worked through individualised booklets, at their own pace, in mixed ability groups. In year 8 they were setted, but continued working through their booklets at their own pace; in year 9 they changed to a class taught textbook system. These differences gave the students extremely interesting insights into setted and mixed ability approaches and it was clear from my case study results that some of the students' responses to their mathematics teaching were related to the setted nature of their experiences. I will now discuss each of these features in turn, starting with the one that seemed to have the most impact upon the largest number of students.

10.2.1 Working at a fixed pace

Probably the main reason that teachers place students into sets in mathematics is so that they can reduce the spread of ability within the class, enabling them to teach mathematical methods and procedures to the entire group, as a unit.

> It's good (setting) because you're putting similar abilities together. I mean it's easier to pitch your lesson, to pitch the work at them, to teach them all together, you know, from the front, as a class. (Edward Losely, mathematics teacher, Amber Hill)

There is evidence that the way in which teachers proceed in setted lessons is by teaching towards a reference group of students (Dahllöff, 1971). Teachers generally pitch their lessons at the middle of the group, on the basis that faster or slower students will be able to adjust to the speed at which lessons are delivered. At Amber Hill many of the students were unable to make this adjustment and when they changed in year 9 from working at their own pace, to working at a fixed pace many students became disaffected and started to underachieve. I have described some of the students' responses to working at a fixed pace in chapter 6. The view that working at a pace which was determined by the teacher, diminished understanding was prevalent both amongst students who found lessons too fast and students who found lessons too slow. But these were not always the same students, almost all of the students seemed to find some lessons, or some parts of lessons, either too fast or too slow:

C: I felt like I was learning - you feel you was learning more, 'cause the teacher would help you - if you went up to him and showed him the book he would help you and I felt I learned more in the first and second year, but in the fourth and fifth year it's more slow and like if you finish first you have to wait for the others, or if you're behind you have to work fast because everyone else is finished.

M: And that's why I don't like maths any more 'cause I can't go at my own pace. (Chris & Marco, AH, year 11, set 4)

The pace that students felt comfortable working at seemed to be determined by a wide range of factors. These included the difficulty of individual topics, the students' own prior experience, individual preferences and, of course, their feelings on that day.

The fact that Amber Hill used setting did not mean that the teachers had to teach students as a group at a fixed pace, but for many teachers the only reason for establishing setted groups is to enable teaching from the front to whole classes. There would be very little point in setting students, given the known disadvantages this confers upon low set students, if the students then worked at their own pace, which they could do in mixed ability groups. At Amber Hill the main purpose of setted groups was also the main source of disaffection for the students as well as the factor that almost all students linked with diminished learning opportunities and under achievement.

The students' second major complaint about setting was also related to class teaching, but it extended beyond this. A major concern of significant numbers of students interviewed was the pressure that they felt was created by the existence and form of their setted environments.

10.2.2 Pressure and anxiety

Many of the Amber Hill students, particularly girls, were anxious about mathematics and the students generally linked their anxiety to the pressure created by setted classes. Some of this pressure derived from the need to work at a pace set by the teacher:

H: I don't mind maths but when he goes ahead and you're left behind, that's when I start dreading going to maths lessons. (Helen, AH, year 11, set 1)

K: I mean she's rushing through and she's going "we've got to finish this chapter by today" but I'm still on C4 and I don't know what the hell she's chatting about and I haven't done any of it, 'cause I don't know it, she hasn't explained it properly she just says "take this off, take that off" and she puts the answers up and like - what?, I don't know what she's doing. (Karen, AH, year 11, set 3)

Another aspect of the students' anxiety related to a more reflective pressure. This concerned the competitive standard that students believed they had to live up to within their setted groups.

H: You're expected to know more.
M: They expect too much, yeah ... you should know this..
H: You should know that...
M: You're the top set. (Helen & Maria, year 11, set 1)

The creation of groups intended to be homogenous in ability caused many students to feel that they were constantly being judged alongside their peers.

L: I preferred it when we were in our tutor groups.
JB: Why?
L: 'Cause you don't worry so much and feel under so much pressure then, cause now you've got people of the same standard as you and they can do the same stuff and sometimes they can do it and you can't and you think oh I should do that and then you can't.. but if you're in your tutor group you're all a different status...it's different. (Lindsey, AH, year 11, set 4)

One of the reasons commonly given for the formation of setted groups is that the competition created by setted classes helps to raise achievement. For some students this was probably true:

B: You have to keep up and it actually, in a way it motivates you, you think if I don't do this then I'll get behind in the class and get dropped down a set. (Gary, AH, year 11, set 3)

However, of the twenty-four students interviewed in year eleven, only one student, Gary, gave any indication that the competition and pressure created by their setted environments enhanced motivation or learning. At Amber Hill setting was a high profile concept and the students were frequently reminded of the set they were in. This served as a constant standard against which they were judged and the students gave many indications that this continual pressure was not conducive to their learning.

10.2.3 Top set experiences

Undoubtedly the most intense pressure in mathematics lessons was placed upon the students in the top set and at Amber Hill placement in the top set appeared to have serious negative consequences for the learning and achievement of some students. Most, but not all, of these students were girls and I described some of the ways in which these students were affected by features of the top set experience in the last chapter.

The top set of my case study year group was taught by the head of mathematics, Tim Langdon, who was, himself, ambivalent about setting:

> '...a lot of people are not prepared to take on board mixed ability and if I'm speaking as a head of department, I'm obviously trying to look to maximise what people I've got in my department in front of me, so if we move the question on to what I can see, I can see a whole bunch of people who are happy with sets, sets by ability and we'll stick with that and look for making them feel comfortable so they're prepared to give me as much as possible. If, from my own point of view, yes I would like some mix of ability within a group because I still feel there's some trickle down effect and still more positive effect within a group with a spread of ability.' (Tim Langdon)

Despite Tim's ambivalence towards the setting process, the environment within his own top set group embodied many of the features which characterise set 1 mathematics groups, particularly rapidly paced lessons, competition between students and pressure to succeed. In my observations of Tim's set 1 class I was often surprised by the pace of the lessons, compared with the lessons he taught to other sets. This seemed to result in wide-spread confusion amongst students who sometimes managed to learn how to use a method, without any understanding of what it meant or when to use it; at other times they did not even manage this. In chapter 6 I showed an extract from Tim's set 1 lesson on factorisation, in which he sped through a number of factorisation examples on the board. Later in that lesson I walked around and talked to students:

> As I walk around the students are factorising their equations by spotting the factors of the number and choosing the factors which add up to the middle number but I don't think the students have any idea what this has to do with the graph, or anything else. TL has divided everything into tiny parts so the whole lesson is now a very segmented process, they find two x numbers at one stage, at another they say which numbers must be added to get 0 but they don't see the links between these. I ask two girls if they know what they are doing, they are both putting their expressions into brackets (correctly) and I ask 'do you know what you are doing that for?' Maria says

'no, I've got no idea', I ask Sara next to her she says 'no, I dunno'. I move around asking different students the same question, by the end of the lesson I have asked at least 14 students and they all say they have no idea. (Year 10, set 1, Tim Langdon)

All of the teachers at Amber Hill taught lessons at a pace that I would regard as reasonably fast, but the set 1 lessons were distinct. The identification of students as set 1 seemed to set off a whole variety of heightened expectations for the teachers about learning capabilities. It was almost as if the teachers believed that they were dealing with a completely different sort of student, one that did not experience problems, one which understood the meaning of examples flashed up on the board for a few seconds and one which could rush through questions in a few moments, deriving real meaning from them as they did so. In the extract below Lorna and Jackie, two of the set 1 girls, described their lessons to me:

L: So he'll go through, like notes on the board and go through questions and ask us questions and then...
J: Leave us to it.
L: But sometimes, when we've got to get a chapter finished, we go through it <u>so fast</u> and sometimes we don't know where we're at, like what we're supposed to have done, what we're, you know, what's coming up.
J: It feels like the teacher's skipping things but he's not, it's just that we've got to go through it so fast.
L: Yeah and sometimes you forget what you've done don't you?
J: Yeah.
L: Like you've just taken one thing in and then you've got to switch to the next chapter or the next piece, it's confusing.
J: Yeah you get really confused. (Jackie and Louise, AH, year 10, set 1)

In interviews the top set students were distinct from students in other groups by virtue of their discourse, in particular, their constant reference to the pace of lessons using words like speed, zoom, fast and whizz:

H: All we've been doing for weeks is practising exam papers, but even that, you just zoom through it, you can't take your own time to do it, and then, it's when you come to the lesson, he's just zooming through it, and still you can't get, you don't understand it properly. (Helen, year 11, set 1)

In order to monitor whether the features of Tim's set 1 teaching were common to other set 1 groups, taught by other teachers, I started to observe lessons from other year groups. This showed that many of the same features, particularly the speed, pressure and competition, were emphasised in other set 1 classes. Indeed, the different set 1 lessons taught by different teachers seemed to have more in common with each other than with lessons taught by the same teachers to different ability groups. Hilary Neville usually took set 3 or 4 classes but she had one set 1 group, in year 7. During my observations of this class I was struck by the similarity between these lessons and other set 1 lessons with different teachers and year groups. Hilary seemed to change into a different teacher for these lessons, she treated the students differently and her explanations were so hurried I would feel under pressure just from watching them. The set 1 lessons in all of the year groups were taught with an air of urgency, almost as though the status of the students meant that the lessons had a completely different agenda to lessons given to students in other groups. The students also reported that the teachers had very different expectations of them because they were in set 1:

JB: Can you tell me about being in set 1?
H: They expect you to know more.
M: Yeah, they expect too much, it's like 'oh you should know this..
H: You should know that.
M: You're the top set.
M : Occasionally they say, you know, this is crap for the top set.
H: Yeah they do that.
M: And he goes <u>fast</u>, like we'll be on one chapter one lesson and the next lesson it'll be "we've done enough of that, go onto the next one".
H: Yeah and it's, Oh my God it's, I mean I know it's the same in every lesson, but they, like set you so much work in maths and they expect you to definitely have it in by next time, and it's .. all subjects do that, but, in maths, it's different.
M: It's tough.
H: Yeah, it's tough. (Helen and Maria, AH, year 11, set 1)

In questionnaires given to the students when they were in year 9 I asked them to describe themselves as 'good', 'OK' or 'bad' at the mathematics they did in school. No girls and only two boys in set 1 described themselves as good at mathematics. In their year 10 questionnaires the students were asked whether they enjoyed mathematics lessons 'always', 'sometimes' or 'never'. The set 1 students were the most negative group in the year, with the smallest proportion of 'always' (0%) and the greatest proportion of 'never' (27% - 6 girls and 2 boys). Sets 1 and 2 between them contributed over two-thirds of the 'never' ratings, from sets 1 to 8 (n = 163).

A number of different research studies have linked mathematical enjoyment with mathematical ability or competence. Understandably, students who are good at mathematics tend to enjoy it, whereas students who experience successive failure in mathematics tend to dislike it. In Amber Hill school the top two sets were made up of students who, at one time, were doing well in mathematics. Despite this, the students liked mathematics less than other students and had less confidence in their own ability to do mathematics. For these students something had clearly gone wrong. During my three years of work at Amber Hill, I became convinced that the negativity of students in set 1 was caused by certain intrinsic features of the set 1 experience. This conviction derived from a number of sources. First, ten of the twelve students interviewed from set 1 expressed a clear preference for mathematics lessons in years 7 and 8 when they worked in mixed ability classes, using an individualised approach:

> J: 'Cause you learned a lot more (in mixed ability groups) and you could recap everything which you didn't understand and spend more time on it, but now you've just got to try and whizz and do your best. (Jackie, AH, year 10, set 1)

Second, in questionnaires given to all of the students in year 10, seventeen of the thirty top set students gave comments similar to the ones below:

> The teacher rushes through methods faster than most pupils can cope.
> The lesson is difficult and we work at such a fast pace that I find it hard to keep up.
> I dislike basically everything. The methods of teaching are too fast and confusing.

Third, when in their year 10 questionnaire the students were asked to name their best ever mathematics lesson, all of the students who described a mathematics lesson (n = 17) chose their coursework projects. Nine other students did not give an answer and four students chose a lesson when a policewoman came in to give a talk about weapons. The seventeen students who prioritised their coursework lessons, over all others, said that they did so because they valued the opportunity to work at their own pace, to find things out for themselves and to experience a less confrontational style of learning.

The set 1 students were a group of very committed and able students who should have been enjoying and succeeding at mathematics. Instead their comments suggest considerable disaffection, particularly because of the speed of lessons and the pressure they experienced. This story of negativity and anxiety was repeated in different top set mathematics groups across Amber Hill school and is a story that, I believe, is repeated in many top set mathematics classrooms across the country for small, but significant groups of students. When my case study group were in year 10 I gave a questionnaire to students in years 9, 10 and 11. The set 1 students across the three year groups responded differently to other students on this questionnaire. For example, set 1 students comprised 26% of the students who said that they never enjoyed mathematics, 38% of the students who described lessons as fast and 27% of the students who said that they were always anxious in lessons, when they should only have contributed towards 19% of these comments. On all of these questions the views of the set 1 students, taught by different teachers, were consistent across the three year groups.

> JB: Can you think of some good and bad things about being in set 1?
> L I can think of the bad things.
> C: I agree.
> JB: OK, what are the bad things?
> L: You're expected to know everything, even if you're not sure about things.
> C: You're pushed too hard.
> L: He expects you to work all the time at a high level.
> C: It makes me do less work, they expect too much of me and I can't give it so I just give up. (Carly and Lorna, AH, year 11, set 1)

The students indicated that the nature of their top set environment had diminished their understanding of mathematics. This idea was validated by a number of the different assessments that have been reported so far. Two class groups at Amber Hill were the focus of the long-term learning study. One was a top set year 9 group, the other a set 4 year 10 group; both taught by the same teacher - Edward Losely. Using chi-squared tests to compare the instances of positive learning, where students learned something and remembered it, with the negative instances, when they learned something during the work but then forgot it, the year 9 set 1 group did significantly worse than the mixed ability year 9 group at Phoenix Park ($p < 0.001$) and the year 10 set 4 group at Amber Hill ($p < 0.001$). Indeed, in this top set group, 10 students out of 22, 45% of the group, attained lower scores in the delayed post-test than they did in the pre-test, taken before the work was introduced to them. This compared with 2 students (14%) from the year 9 Phoenix Park group and no students in the year 10 set 4 group at Amber Hill.

Although this research was of a small scale it showed quite clearly that the learning of the year 9 top set students, on the particular piece of work assessed, 'rates', was extremely ineffective and, for almost half of the group, it may even have been detrimental. Nothing about this work made it distinct from any other piece of work the students did and in my observations of their lessons on 'rates' the students were motivated and worked hard. Edward taught them methods, at the usual pace for the class, the students watched, listened and then practised the methods, as was normal for the school. The results of this research may, perhaps, be explained by some of the views of the year 11 students about the stability of their top set learning:

> JB: How long after you have done work do you think you can remember it and use it?
> M: Ten minutes.
> H: I've forgotten it straight after the lesson.
> JB: How much of something would you be able to remember, say, 6 months after doing it?
> M: None at all.
> H: Oh no, oh my God no. (Helen and Maria, AH, year 11, set 1)

The students in my top set case study group also attained the lowest grades, of sets 1 to 4, on both aspects of the applied architectural activity and the area question in the flat design activity. The students in set 1 seemed to have particular difficulty working out what they should do within these assessments, probably because they had learned methods at a faster pace than other students and were particularly prone to making 'cue-based' decisions in an attempt to get by in lessons. Further indication of the difficulties experienced by top set students was provided by the conceptual and procedural results reported in chapter 7. These showed that students who took the higher level examination paper, in the top set at Amber Hill, were less able than other students to answer conceptual questions and this contrasted strongly with the higher level students at Phoenix Park. The top set students showed in three different assessments that their learning of mathematics may have disabled them in a variety of situations.

The third major complaint of the students at Amber Hill was particularly prevalent amongst students outside of set 1 and it related to the way in which setting limited their potential opportunities and achievements.

10.2.4 Restricted opportunities

In interviews many of the students at Amber Hill expressed clear feelings of anger and disappointment about what they felt to be unfair restrictions upon their potential mathematical achievement. The students, from a variety of sets and ability ranges, cared about their achievement, they wanted to do well and they were prepared to put effort into their work, but many felt that they had been cheated by the setting system:

> L: The thing I don't like about maths is .. I know because we're in set 4 you can only get a D.

S: Yeah you can't get any higher than a D.

L: So you don't do as much.

S: Yes you could work really hard and all you can get is a D and you think, well what's the point of working for a D? (Lindsey and Sacha, AH, year 11, set 4)

A: I'm in set 3 and the highest grade I can get is a C... it's silly because you can't, maybe I wanted to do A-level, 'cause maths is so useful as an A-level, but I can't because...I can get a C if I really push it, but what's the point? (Alan, AH, year 11, set 3)

A number of the students explicitly linked the restrictions imposed by the set they were in to their own disaffection and underachievement. They reported that they simply could not see any point in working in mathematics for the grades that were available to them:

JB: How would you change maths lessons? If you could do it any way you wanted what would you do?

C: Well work at your own pace and different books.

JB: How would working at your own pace help?

M: Well it would encourage people more wouldn't it?, they'd know they're going for an A wouldn't they? like what's the point of me and Chris working for a D? Why are we gonna work for a D?

C: I'm not saying it's not good a D, but...

M: It's <u>not</u> good, it's crap, they said to us if we get 100% in our maths we're gonna get a D, well what's the point? (Chris & Marco, AH, year 11, set 4)

These extracts raise questions about the accuracy of the students' assessments of their own potential but, in many ways, the degree of realism in the students' statements is irrelevant. For what the students clearly highlight is the disaffection they felt because of their setting arrangements. The students may have been unrealistic, but the disaffection they experienced because of their restricted attainment was real.

S: We're more to the bottom set so we're not expected to enjoy it.

JB: Why not?

S: I'm not putting, I'm not saying 'cause we're in the lower set we're not expected to enjoy it ... it's just... you're looking at a grade E and then you put work in towards that ... you're gonna get an E and there's nothing you can do about it and you feel like...what's the point in trying, you know? what's the difference between an E and a U?

JB: How did you feel about maths before you were put into sets?

K & S: Better. (Keith & Simon, AH, year 11, set 7)

These feelings of despondency were reported from students in set 2 downwards and many of the students suggested that the limits placed upon their attainment had caused them to give up on mathematics. The students believed that they had been restricted, unfairly and harmfully, by their placement into sets.

The fourth and final response that prevailed amongst students primarily affected the students in low sets and this related to the way in which the sets were chosen.

10.2.5 Setting decisions

Many of the students interviewed did not feel that the set that they had been put into was a fair reflection of their ability:

> S: I was alright in the first year, but like me and my teacher had a few problems, we didn't get on, that's why I think it's really better to work really hard in the first years, 'cause that's when you've got a chance to prove a point, you know, that you're good and then in the second year you'll end up in a good set and from then on you can work. But me in the first year, I got dumped straight into the bottom set. And I was like huh? what's going on?, you know? and they didn't teach me anything there and I was trying hard to get myself up, but I couldn't, 'cause once you're in the bottom it's hard to get up in maths. That's another bad thing about it, and other people now, there's people now in like higher sets man and they just know nothing, they know nothing. (Simon, AH, year 11, set 7)

Some of the students, particularly the boys, felt the set they were in reflected their behaviour more than their ability:

> M: Yes but they're knocking us down on our behaviour, like I got knocked down from second set to bottom set and now, because they've knocked me down, they've thrown me out of my exams and I know for a fact that I could've got in the top A, B or C. (Michael, AH, year 11, set 7)

Tomlinson (1987) provides evidence that the behaviour of students can influence the examination groups which they are put into and some of the Amber Hill students were convinced that their behaviour, rather than their ability, had determined their mathematics set, which in turn, had partly determined their examination grade.

10.2.6 Amber Hill summary

The students at Amber Hill were coherent in their views about setting. The twenty-four students interviewed in year eleven were in general agreement about the disadvantages they perceived and all but one of the students interviewed expressed strong preferences for mixed ability teaching. This was because setting, for many of the students, meant one or more of:

- a lack of understanding, when the pace of lessons was too fast;
- boredom when the pace of lessons was too slow;
- anxiety, created by the competition and pressure of setted environments;
- disaffection related to the restricted opportunities they faced; and
- perceived discrimination in setting decisions.

It was also clear from the students that setting did not have a single influence that affected all students in the same way. Some students were probably advantaged by setted lessons, but others had been negatively affected by processes of setting. In almost all cases the disadvantages students reported concerned their learning of mathematics and their subsequent achievement. Nevertheless, some students also experienced other negative repercussions:

> K: You walk around the school and you get people in the top set and you get people in our set and if you walk round the school and you're talking about maths, they put you down because you're not in that set, it's like...
> S: They're dissing you and that.
> K: They're saying you haven't got the ability they've got. (Keith & Simon, AH, year 11, set 7)

Despite the labelling associated with setting, the major concern for the majority of students interviewed was the consequences setting might have for their achievement. In section 10.3 I shall present various forms of data that give some indication of the way in which the students' achievement was affected by their placement in sets.

10.3 Setting and Achievement

The students' different responses to setting, given in interviews, indicate that the success or failure of a student in a setted group related to their preferred learning style and their responses to competition, pressure and opportunity (or lack of it). Various quantitative indicators add support to the idea that success was strongly related to factors other than ability. For example, at Amber Hill, there was a large disparity between the attainment of students when they entered setted lessons and their success in GCSE examinations at the end. This may be demonstrated through a consideration of the students' scores on their NFER tests at the end of year 8 and their scores on their GCSE examinations at the end of year 11. This information is provided for both of the schools, providing an insight into the different implications of setted and mixed ability teaching for students' achievement.

At Amber Hill a high correlation would be expected between NFER results at the end of year 8 and eventual achievement, because the students were setted largely on the basis of their NFER results and, once inside their sets, the range of their attainment was severely restricted. At Phoenix Park a smaller correlation would be expected, because prior to their NFER tests the students had attended fairly traditional middle schools. At Phoenix Park they experienced considerable freedom to work if and when they wanted to in lessons which, combined with the openness of the school's teaching approach, may have meant that some students would not perform at the end of year 11 as would be expected from their performance at the end of year 8. However, a comparison of performance, before and after setting and mixed ability teaching at the two schools gives the following scattergraphs:

Figure 10.1 Relationship between GCSE grade and NFER entry scores at Amber Hill

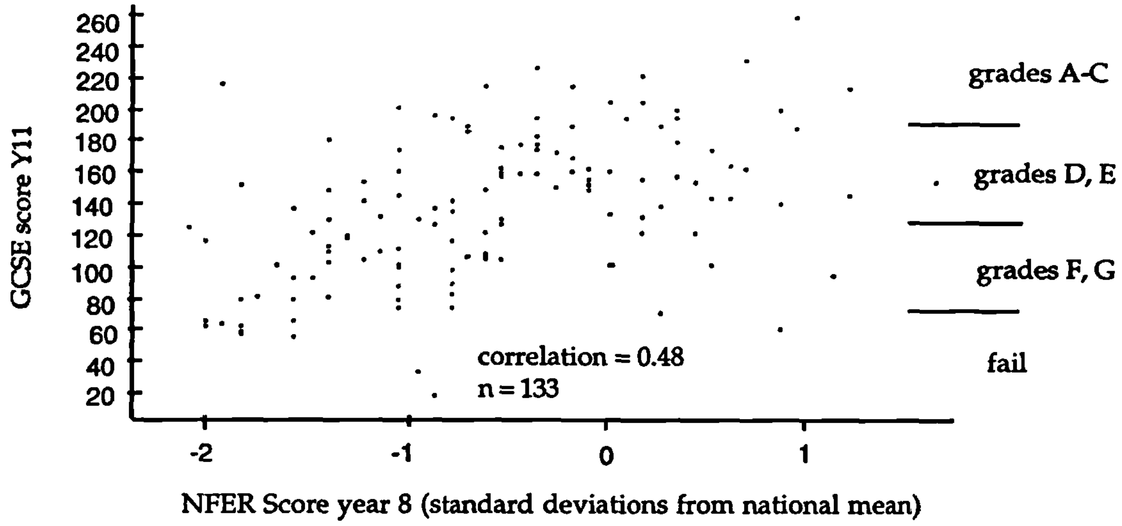
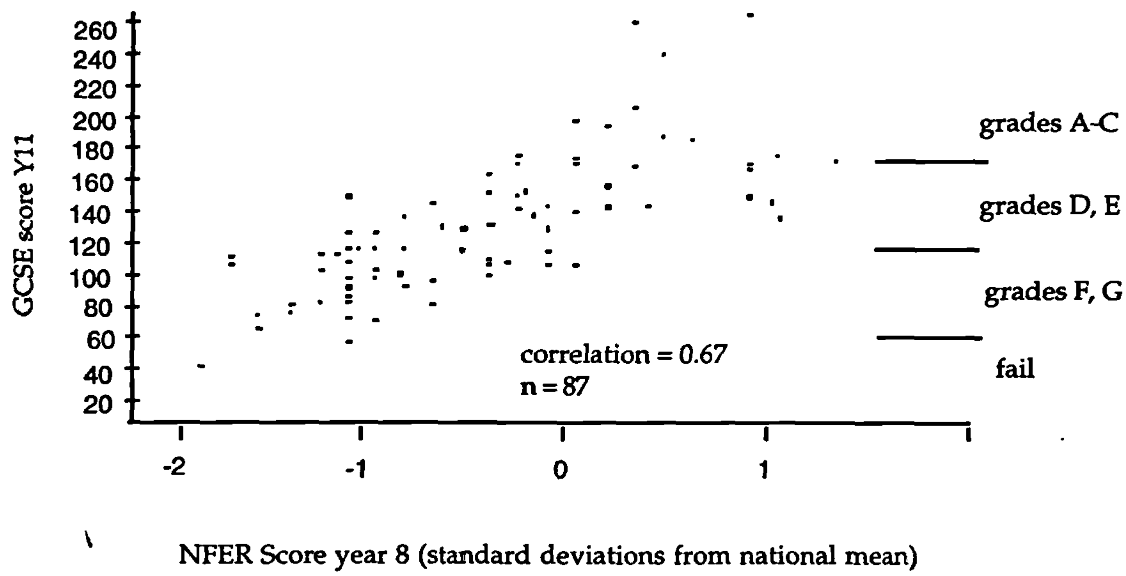


Figure 10.2 Relationship between GCSE grade and NFER entry scores at Phoenix Park



[NB: the actual GCSE *scores* at the two schools are not directly comparable because the schools used different examination boards.]

These scattergraphs display an interesting phenomenon. They show that at Amber Hill there was a relatively small relationship between the students' attainment in year 8 and their eventual success, after three years of working in setted lessons, demonstrated by a c rrelation of 0.48. This meant that some students did well, even though indications in year 8 were that they were not particularly able and some students did badly, despite being high achievers at the end of year 8. At Phoenix Park where students were taught in mixed ability groups and given considerably more freedom, there was a correlation of 0.67 between initial and eventual attainment. These results support the idea that once inside a setted group a number of factors, that are relatively independent of initial attainment, influence a students' success.

A second interesting phenomenon was revealed at Amber Hill through a consideration of the relationship between social class and the set students were placed into. This relationship was examined at both schools because the students were put into setted examination groups at Phoenix Park in the middle of year 11. Partial correlations from the two schools enable the impact of 'ability' (measured via NFER tests) and social class upon the sets students were given, to be considered. These showed that at Amber Hill the correlation between the social class of students and the set they were placed into was 0.25, after ability was controlled for, with students of a 'low' social class being more likely to appear in a low set. A similar analysis of partial correlations at Phoenix Park showed that there was a small, negative correlation of -0.15 between social class and examination group, after the effect of ability was taken out. This showed that at the end of their mixed ability teaching experiences there was a small tendency for students of a 'lower' social class to be placed into a higher examination group at Phoenix Park.

Another way of looking at this relationship is to consider the two-way correlations between different variables. At Amber Hill there was a small correlation between the results of the students' NFER tests and their social class, of 0.19. However, when the teachers placed the students into sets, the correlation between set and social class increased to 0.3, despite the fact that setting decisions were partly based upon the students' NFER scores. At Phoenix Park the students took NFER tests on entry to the school and at this time there was a large correlation between NFER test results and social class of 0.43. I do not have the data to explain why the students left their middle schools with this apparent class bias, however, when Phoenix Park placed the students into sets at the end of year 11 and the end of their mixed ability teaching, the correlation between set and social class had drastically reduced to 0.15. Thus, it seems that at Amber Hill the students started the school with relatively little class based achievement, but this increased when the students were setted. At Phoenix Park the students started the school showing evidence of class based achievement, favouring the middle classes, but this had disappeared, almost entirely, by the time they reached the end of year 11. One possible factor influencing the change between middle school and Phoenix Park was that all of the middle schools that the students attended, set the students for mathematics.

Further insight into the possibility of class bias at Amber Hill is demonstrated by locating individuals at the two schools who 'under' or 'over' achieved, in relation to their initial ability scores. At Amber Hill approximately 20% of the students (n = 22) could be described as 'outliers' on the scattergraph. The twenty-two most extreme outliers on the graph were made up of 7 'over' achievers and 15 'under' achievers. Closer examination of these students gives the following sex and class profiles:

Table 10.1 Amber Hill Over achievers

	middle class			working class		
social class:	1	2	3	4	5	6
girls			1			1
boys		4	1	1		

Table 10.2 Amber Hill Under achievers

	middle class			working class		
social class:	1	2	3	4	5	6
girls			2	4	1	2
boys	1			5		

These tables show that amongst the over achievers there was a ratio of 3:1 of middle class to working class students, who were mainly boys. Amongst the underachievers there was a ratio of 1:4 of middle class to working class students, made up of roughly even numbers of girls and boys. These outliers represent only a small proportion of the students at Amber Hill but they show quite clearly that those students who did better than would be expected from their initial ability scores tended to be middle class boys, whereas those who did worse tended to be working class students (of either sex). This is interesting to contrast with the most extreme 20% of Phoenix Park students (n = 18). These students did not 'under' or 'over' achieve to the same extent as the Amber Hill students, as can be seen from the scattergraphs. However, the students who were nearest to the edges of the graph did not reveal any class polarisation in achievement at Phoenix Park:

Table 10.3 Phoenix Park Over achievers

	middle class			working class		
social class:	1	2	3	4	5	6
girls					1	
boys		1	1	4		

Table 10.4 Phoenix Park Under achievers

	middle class			working class		
social class:	1	2	3	4	5	6
girls		1	2	1		
boys		1	1	2	1	2

These tables show that amongst the over achievers at Phoenix Park there was a ratio of 2:5 of middle class to working class students. Amongst the underachievers there was a ratio of 5:6 of middle class to working class students. The over achievers at Phoenix Park were generally working class boys, whereas the under achievers were roughly equal numbers of middle class and working class girls and boys.

What these results indicate is that at Amber Hill the disparity between initial mathematical capability and eventual achievement shown on the scattergraph is partly created by a small number of mainly middle class students who achieved more than would be expected and a relatively large number of mainly working class students who achieved less than would be expected. Similar evidence of class polarisation is not apparent at Phoenix Park. This quantitative analysis enables social class to be added to the list of factors that appeared to influence achievement in setted lessons, it also re-establishes the notion that success in a setted environment had little to do with 'ability'. The influence of class bias over setting decisions is well documented (Ball, 1981; Tomlinson, 1987) and some of the students gave some indications, in interviews, about the way that this process may have taken effect. In the following extract Simon, a working class student, talked about the way in which he opted out of the 'game' of impressing the mathematics teacher:

> S: Yes and in a way right, when I came to the school, I was scared to ask questions man, so I just thought, no forget it man. (Simon, AH, year 11, set 7)

This withdrawal because of Simon's fear probably served to disadvantage him when setting decisions were made The disproportionate allocation of working class students to low sets shown by the correlations at Amber Hill would certainly have restricted the achievement of working class students. However, it seems likely that the social class of students may also have affected the way in which individuals responded to the experiences of setted lessons. In the next section I will attempt to draw together the various results that have been reported so far, in order to illuminate the different factors that influence a students' achievement in setted and mixed ability groups.

In any debate about the implications of setted and mixed ability groups it is important to consider the achievement of students. The approaches of Amber Hill and Phoenix Park schools differed in many important ways but the GCSE results reported in chapter 7 show that the setted classes did not achieve better results than the students in the mixed ability classes, despite the increased time spent 'working' by the Amber Hill students. The students who learned mathematics in an open approach in mixed ability classes, achieved significantly more A-G grades ($\chi^2 = 12.5$, 1 d.f. $p < 0.001$), despite the comparability of the two cohorts of students on entry to their schools.

10.4 Discussion and Conclusion

At Phoenix Park school the students experienced a great deal of freedom to work when they wanted to work and talk or wander about when they did not. The students were grouped in mixed ability classes, the high ability students were not placed in high sets that would push them, the low ability students were not placed in sets in which teachers could concentrate upon their individual needs. At the end of three years of this relaxed and open approach the students who did well were those of a high ability. Students who did exceptionally well, compared to their entry scores were mainly working class students, those who did exceptionally badly were both working class and middle class students.

In all of these respects Amber Hill differed from Phoenix Park and although setting and mixed ability teaching was not the main focus of my research study, there were a number of clear indications from various forms of data, that at Amber Hill:

• social class influenced setting decisions resulting in disproportionate numbers of working class students to be allocated to low sets

• significant numbers of students experienced difficulties working at the pace of the class resulting in disaffection and reported under achievement

• students became disillusioned and de motivated by the limits placed upon their achievement within their sets

• some students responded badly to the pressure and competition of setted lessons, particularly girls and students in top sets.

For a student, being able and hard working at Amber Hill was not a guarantee of success within their setted classrooms. Indeed the students indicated that success depended more upon working quickly, adapting to the norms for the class and thriving upon competition than anything else. A number of different results from this study cast doubt upon some wide-spread beliefs about setted teaching. For example, there was no qualitative or quantitative evidence that setting raised achievement, but there was evidence that setting diminished achievement for some students. A comparison of the most able students at the two schools showed that the students achieved more in the mixed ability classes of Phoenix Park than the high sets of Amber Hill. This may be related to a number of features of the two schools' approaches, but there were many indications from the top set students at Amber Hill that features of their top set learning had diminished their achievement. The various forms of data also seem to expose an important fallacy upon which many setting decisions are based. Students of a similar 'ability', assessed via some test of performance, will not necessarily work at the same pace, respond in the same way to pressure or have similar preferences for ways of working. Grouping students according to ability and then teaching towards an imaginary model student who works in a certain way at a certain pace, will almost certainly disadvantage students who deviate from the ideal model. The stress and anxiety reported by the students in interviews at Amber Hill is probably an indication of this phenomenon. There was much evidence that the students who were disadvantaged by this system were predominantly working class, female or very able. The class polarisation that existed within the setted system of Amber Hill and that was completely absent at Phoenix Park is consistent with the results of other research studies that have considered the links between setting and class bias (Abraham, 1995; Tomlinson, 1987; Ball, 1981; Lacey, 1970; Hargreaves, 1967). A common feature that links all of the findings of this study concerns the individual nature of students' responses to setting. Students at Amber Hill responded to setting in a variety of different ways indicating that it is too simplistic to regard the effects of setting as universally good or bad for all students, even students in the same set. The various quantitative studies that have compared the group scores of setted and mixed ability classes overlook this fact and, in doing so, overlook the complexity of the learning process for different individuals.

To conclude, survival of the quickest is probably not the most accurate way to describe the experiences of setted students, for this research has indicated that it was the students who were most able to adapt to the demands of their set who were most advantaged, or least disadvantaged by setting. In predicting who those students may be, it seems fair to assume that if a student is middle class, confident, thrives on competition and pressure and is motivated, regardless of limits on achievement, they will do well in a setted system. For the rest of the students success will probably depend upon their ability to adapt to a model of learning and a pace of working which is not the most appropriate for their development of understanding.

The consequences of setting and streaming decisions are great. Indeed, the set or stream that students are placed into, at a very young age, will almost certainly dictate the opportunities they receive for the rest of their lives. It is now widely acknowledged in educational and psychological research that students do not have a fixed 'ability' that it is determinable at an early age. However the placing of students in academic groups often results in the fixing of their potential achievement. Slavin (1990) makes an important point in his analysis of research in this area. He notes that as mixed ability teaching is known to reduce the chances of discrimination, the burden of proof that ability grouping is preferable must lie with those who claim that it raises achievement. Despite the wide range of research studies in this area, this proof has not been forthcoming.

Chapter 11 Reflections on the Study

11.1 Introduction

In this chapter I shall reflect upon the various results and findings that have been introduced as part of this study. In the first instance I will consider the implications of the research for the use of different methodologies, I will then consider the way in which evidence has informed, supported or contradicted current theoretical perspectives. In the final part of the chapter I will locate the results of the research within the wider political perspective that was briefly introduced at the start of the thesis. I shall then relate the different findings to moves to displace progressive education and further the use of 'back to basics' approaches within classrooms.

11.2 Research Methodologies

A number of studies (Athappilly, Smidchens and Kofel, 1983; Resnick, 1990; Maher, 1991; Sigurdson & Olson, 1992; Keedy & Drmacich, 1994) have shown that students attain higher grades in response to open teaching approaches, but few of these studies have examined the *way* in which particular features of different approaches inhibit or enhance learning. In this study I have attempted to investigate the nature and form of the processes which influence students and the way in which these take effect. In order to do so I have employed both qualitative and quantitative methods and my claims for rigour rest heavily upon the triangulation of different findings. It has been fortunate for this research, although clearly not for the students, that the Amber Hill approach had an extreme impact on the students, because it helped to crystallise the problems of the approach and to isolate those features which influenced the students' responses to mathematics. But the flexibility to respond to significant characteristics of the two schools was provided by the ethnographic nature of the study. This allowed me to interpret events in the two schools and design ongoing fieldwork accordingly.

Research in mathematics education is dominated by quantitative techniques and methods. This study has indicated, I hope, the potential of multi-method, ethnographic accounts in documenting and understanding different aspects of students' experiences. Even so, it might be possible to challenge the results of this research or attribute them to factors which have not been discussed, such as how good the teachers were at Phoenix Park. But part of the value and power of ethnographic methods is the flexibility they allow researchers to consider and investigate the importance of different factors in a holistic and exhaustive fashion. After hundreds of hours spent in the classrooms at the two schools, after hearing the students' own accounts of their learning, after analysing over 200 questionnaire responses each year and after consideration of the results of various different assessments; I have been able to consider the factors that were influential in the students' development of understanding. The findings of this research indicate that the main sources of influence within the Phoenix Park approach were the open nature of the mathematics, the choices the students were given and the requirement they faced to think and use their initiative in mathematical situations. These were all features that were encouraged by their teachers but the students were not responding to individual teacher characteristics related, for example, to their popularity or the methods that they used to explain mathematics. The identification and exploration of these factors would not have been possible without the availability of a variety of different data sources, designed and mobilised in response to events within the field, and the integration of qualitative and quantitative methods.

11.3 Theoretical Perspectives

In this thesis I have attempted to tell the story of the mathematics teaching and learning in two schools. There are a number of theoretical perspectives that might be used to explain or interpret the findings from these schools. For example, the two approaches could be taken as examples of constructivist and non-constructivist teaching, or as exemplifications of problem solving and computational approaches to mathematics. I have chosen to analyse the results from a perspective of situated cognition because this provided a framework that addressed the way in which individuals dealt with different situations. The breadth of this framework was fundamental in understanding the reasons why students used mathematics in one setting and not another; why they appeared to have knowledge, but they did not always choose to use it. The findings of this study, interpreted within this framework, show that learning is an inherently complex process and that it is wrong to believe that assessments merely indicate whether a student has *more* or *less* knowledge. Interpretations of learning, knowledge and assessment need to include consideration of the different forms of knowledge that individuals possess, the goals they form in different situations and the way in which individuals understand and perceive settings.

At Amber Hill many of the students appeared to be disadvantaged in the face of new or applied situations. This seemed to be due to a combination of the students' perceptions about mathematics, their understanding of mathematics and the goals they formed in different settings. The students believed that mathematical success required memory, rather than thought. They had developed a shallow and procedural knowledge that was of limited use in demanding situations, and their desire to interpret cues and do the 'right thing' suppressed their ability to interpret situations holistically or mathematically. Lave (1988, Lave & Wenger, 1991) has proposed that notions of transfer cannot explain the way individuals use knowledge in different settings because transfer theories do not take account of the 'communities of practice' in which people work. The results of this study support this view on a number of different levels. For example, the Amber Hill students regarded the mathematical classroom as a highly specialised community of practice that was different from all others. This idea was formed in response to various aspects of their setting, such as the formalised nature of the mathematics they encountered, the lack of social interaction in their classrooms, the imposition of school rules and the goals of lessons. These all helped the students to locate their mathematical knowledge within the four walls of their mathematics classrooms. At Phoenix Park the boundaries between school and the 'real world' were less distinct. This appeared to stem from a number of features of the school's approach, including the fact that students were encouraged to use mathematics in order to solve the problems that *they* had posed.

A second important difference between the students at the two schools also relates to Lave's relational view of learning (1993, 1996a) and it concerns the students' interpretation of mathematical situations. When the Phoenix Park students encountered a mathematical problem, they believed that they should consider the different variables present and form knowledge in relation to the setting they were in. They were not disabled by the need to try and remember relevant algorithms. When the students described their use of mathematics they talked about the importance of thought, their adaptation of methods they had learned and their interpretation of different situations. Some students specifically refuted the notion that they would remember a piece of knowledge from their lessons, instead they described the way in which they took ideas from lessons and re-formed them in response to different situations. Their descriptions were inconsistent with notions of transfer but entirely consistent with Lave's 'relational' view of learning (1993, 1996a). At the start of this research study I set out to monitor the factors that affected students' ability to 'transfer' their learning. I now support Lave's view that this is an entirely inappropriate way to conceptualise the way individuals use mathematics in different settings and this conviction partly derives from the Phoenix Park students' descriptions of their learning and partly from the behaviours of the students at the two schools. Resnick (1993) has claimed that we are currently 'in the midst of multiple efforts to merge the social and the cognitive' (1993, p3 and we are witnessing a radical reconstruction of the way that learning is viewed. The reports of the Amber Hill and Phoenix Park students seem to add support to the new, relational idea of knowing that is emerging from this perspective (Resnick, 1993; Lave, 1993, 1996a). They also contradict certain aspects of this perspective as they suggest that different forms of learning can enculturate students into a way of thinking and interpreting the world that advantages them in different communities of practice.

The results from Amber Hill and Phoenix Park have also both supported and challenged different gender perspectives within the field of education. At Amber Hill many of the girls underachieved in mathematics, they demonstrated anxiety and they were disaffected. But the girls did not 'attribute' the 'blame' to themselves. They offered coherent accounts of their desire to understand mathematics and the way in which they believed their school's textbook approach denied them access to understanding. The girls were clear that their mathematical understanding would have been enhanced if they had been given more opportunity to work in an open way, at their own pace and in groups. In previous years authors have proposed that intervention strategies be used to try and change girls, in order that they may fit into a fixed model of mathematics teaching (Kaiser-Messmer & Rogers, 1994). The girls at Amber Hill supported the idea that equity in mathematics education is more likely to be achieved if mathematical epistemologies and pedagogies are changed (Burton, 1986a, 1986b, 1995). This notion was also supported by the fact that the open, process based approach at Phoenix Park seemed to have drastically alleviated under achievement and anxiety amongst girls.

11.4 National and Political Perspectives

11.4.1 Transmission teaching

Ball (1993) has described a Conservative vision for education in which desks are 'in rows, the children silent, the teacher 'at the front', chalk in hand, dispensing knowledge' (Ball, 1993, p 209). This vision, which is increasingly consistent with the education policies of 'New Labour', is represented by the mathematics classrooms at Amber Hill. In these classrooms there was an emphasis upon order and control, the learning of set, traditional mathematical methods, 'chalk and talk' transmission teaching and children divided into eight narrow bands of 'homogeneous' ability. This research study has shown that every one of these traditional features of Amber Hill's mathematics teaching disadvantaged some students in some way. This was not because of teachers who were incompetent or who lacked commitment. It was because of the pedagogical, philosophical and epistemological models embraced by the teachers. Neither were the problems experienced by the students due to their own inherent inadequacies. For example, it was possible to observe a completely different educational approach that was open, relaxed and 'progressive', in the same school with the same students, by just walking down the corridors and stepping into the English classrooms. Here the students would be discussing work, analysing, debating and using their own ideas and, in response to this, achieving greater understanding and higher examination grades (see appendix 26).

The teachers at Amber Hill believed in giving students structured pieces of mathematical 'knowledge' to learn, in line with what Ball (1993) has called the 'curricular fundamentalism' of the Conservatives (1993, p205). The teachers did not perceive a real need to give students the opportunity to think about, use or discuss mathematics. Sigurdson and Olson (1992) note that many teachers consider learning and understanding to be synonymous and, because of this, much of school learning is done at rote level. The Amber Hill teachers fitted into this model — they did not see any real difference between a clear transmission of knowledge and student understanding. The majority of the problems at Amber Hill derived from this knowledge transmission approach, which was a central feature that shaped mathematics teaching at the school. Other traditional features of the students' environment, such as setting and high pressure learning, served to exacerbate the students' problems, but it was the transmission of closed pieces of knowledge that formed the basis of the students' disaffection, misunderstandings and under achievement.

11.4.2 Setting policies

The setting of students into homogeneous ability groups is a central part of Conservative and, more recently, Labour party education policies (*Times Educational Supplement* 14/6/96 p 7, *The Guardian*, 8/6/96). Such policies do not only concern students in secondary schools, in 1993 all primary schools were sent reports from both the National Curriculum Council (1993) and the Department for Education (circular 16/93) which explicitly encouraged them to introduce or re-introduce setting. The main argument given for the use of setting is that it raises achievement, particularly for students in high sets. Set against this, many of the students in high sets at Amber Hill, in a number of different year groups, suffered because of their placement in these groups. The teachers of these groups were not particularly authoritarian or supporters of competitive approaches to schooling, but the environments generated within their top set classrooms still induced extreme anxiety amongst many of the students. The 'top set effect' that the students described did not affect all students equally. It served to discriminate at least partly on the basis of sex and a large proportion of the girls in the top set underachieved because of setting. Speed, pressure and competition are all features of classrooms that are implicitly encouraged by

Conservative education policies as ways of bringing about higher attainment. For the students at Amber Hill these policies encouraged misunderstanding and a hatred of mathematics and, in the GCSE examination, they resulted in lower grades than might have been possible in different circumstances. But the disadvantages linked to setting did not only affect students in the top sets. Students throughout the setting spectrum reported that their learning was diminished by having to work at the pace of the class, as well as the restrictions placed upon their learning opportunities and potential achievement by the setting structure and its role in curricula differentiation. This did not disadvantage all of the students, some students were probably advantaged by setting, but the picture was very much more varied than proponents of setting lead people to believe. Within this research study, success in a setted mathematics group was not only determined by mathematical ability but by social class, sex, confidence and the ability to adapt to an imposed pace of working.

11.4.3 Flexibility

Noss (1994, 1991) regards the teaching of flexibility and adaptability as the most important role for mathematics education in the future, because of the development of technology and the changing nature of the job market. The Amber Hill teachers emphasised control and order in their classrooms and encouraged students to follow set methods and rules. These features were, in many ways, incompatible with critical thought and analysis. The students at Amber Hill were not flexible or adaptable in their approach, they did not think critically in mathematical situations and they demonstrated passive, unchallenging acquiescence in lessons. This behaviour appeared to be a direct result of school conditioning towards conformity, order and obedience; an acceptance of school and mathematical rules and a dependence upon the structures provided by these rules. One of the results of this dependency was that the students were extremely well behaved throughout their mathematics lessons. A more important result was that they lacked critical thought and this certainly disadvantaged them in situations that required their use of mathematics.

In the UK the government encourages such 'basic' tenets of education as knowledge transmission, setting and control and order; at the same time they continue to spend money on programmes that are intended to increase the capabilities of school leavers. These policies are unstable and contradictory: in stressing both a concern for and emphasis on 'basics', related to knowledge and conformity, they are reducing the ability of schools to produce flexible workers capable of initiative. At Amber Hill, it was the very mathematical and school characteristics that were encouraged, implicitly and explicitly by current government reforms, that produced the antithesis of the type of understanding, critical thought and reasoning most needed by school leavers moving into the twenty-first century.

11.4.4 Progressivism

The term 'progressive' is a label that is often used in a pejorative way to describe ineffective teaching approaches. The Phoenix Park approach was based upon principles of independence and self-motivation and such a label does not begin to reflect the complexity of the different characteristics which contributed towards the school's approach. However, I have chosen to adopt this term to describe the combination of the school's different features, partly in order to juxtapose the Phoenix Park approach with the back-to-basics movement and partly because Phoenix Park school embraced many of the principles that traditionalists most fear when they talk about progressive education. At Phoenix Park the students were schooled in a totally different way from the students at Amber Hill and although the most obvious result of the school's 'progressivism' and lack of imposed order was classrooms that many would describe as chaotic, results from this study have shown that the students learned more effectively than the Amber Hill students. The Phoenix Park students reported that they developed self motivation and self discipline as a result of the school's approach, that the openness of their work caused them to think for themselves and the need to use mathematics in different activities caused them to be adaptable and flexible in their approach to mathematics. The general lack of school rules also seemed to produce students who were confident and creative in their response to different situations. Whilst it was the traditional features of Amber Hill school's teaching that appeared to disadvantage their learning, it was the progressive features of Phoenix Park school that served to create students who were generally confident, creative and flexible. The students at Phoenix Park were less constrained and confined and this seemed to have had a significant positive impact upon the way in which they viewed situations and took decisions.

I do not wish to imply that Phoenix Park represented the idealised learning environment, it clearly did not, but a consideration of the ways in which lessons could have been improved did not suggest a move towards the Amber Hill model of teaching. For example, limited classroom observations may suggest that more of the students at Phoenix Park should be encouraged to work, but the students at both schools showed quite clearly that merely making them work did not improve their learning. In addition, GCSE results showed that Jim's relaxed classes did as well as the classes of stricter teachers at Phoenix Park (see appendix 27) and the students who were badly behaved at Phoenix Park were equally represented amongst the students who over and under achieved at GCSE, compared to their entry NFER scores (see appendix 25). Students at Phoenix Park worked when they chose to work but they still attained more than the disciplined students at Amber Hill. All of these results indicate that the most important aim for teachers is to engage students and to provide worthwhile activities that they find stimulating. This is supported by the work of Bell (1993), who found that intensity and degree of engagement were more important than time on task. This intensity is difficult to achieve all the time, but the Phoenix Park students at least experienced real engagement for some of their school lives. When the two boys, reported in chapter 6, discovered the way in which they could use trigonometry in order to find an area they were genuinely interested and excited. The contrast between this and the Amber Hill students' learning of trigonometry could not be more extreme. The findings of this research indicate that lessons in both schools would be improved if students experienced this sort of excitement and engagement more often. But the key to this improvement has to be the design of appropriate activities and the creation of stimulating work environments, not a simple increase in discipline and order. Thus if Phoenix Park's mathematics approach were to be improved this would require a reaffirmation of this 'progressive' principle, not a move towards a traditionalist control and transmission model.

11.4.5 The 'falling standards' debate

Mathematics education has recently taken a leading role within public debates in response to claims of falling standards, poor performance in international studies and badly prepared university students (London Mathematical Society, 1995; *Panorama*, 3/6/96). Such reports have re-opened debates about the relative advantages of traditional, 'back to basics' approaches to teaching as against the 'progressive' methods, which are commonly cited as culprits in these accounts. But these debates rarely draw upon any evidence or research. A number of different research projects within mathematics education have contrasted open, progressive or meaning-based approaches to mathematics teaching with closed, traditional, algorithmic approaches (Resnick, 1990; Maher, 1991; Sigurdson & Olson, 1992; Keedy & Drmacich, 1994). These studies have *all* shown that progressive approaches to teaching result in increased attainment, even on traditional tests that are not compatible with the teaching approaches used. Athappilly, Smidchens and Kofel (1983) conducted a meta-analysis, which summarised 30 years of experiments comparing modern and traditional mathematics teaching. This analysed the results of 134 controlled outcome studies and found that 'the average person receiving some form of modern mathematics treatment is 0.24 standard deviations in achievement and 0.12 standard deviations in attitude above an average student not receiving modern mathematics' (Athappilly, Smidchens and Kofel, 1983, p491). These studies cast serious doubts upon the claim that progressive mathematics education has lowered achievement, a claim that is made even more untenable by a consideration of the way mathematics is commonly taught. A large body of international research (Peterson & Fenema, 1985; Romberg & Carpenter, 1986) and a range of HMI reports from this country (1985, 1992) have shown that Amber Hill's mathematics approach was not at all unusual. Sigurdson and Olson (1992) report that most of school mathematics learning is rote and most mathematics tests assess low-level mathematical procedures. Peterson (1988) reports that the majority of mathematics teaching is focused upon the teaching and learning of basic facts and algorithmic procedures and Cheek and Castle (1981) question whether the term 'back to basics' can be applied to mathematics education when evidence shows that a basic approach was never abandoned by the majority of mathematics teachers. They point to research that has shown that 'mathematics instruction has changed little over the past 25 years, despite the innovations advocated' (1981, p264) and that a single textbook continues to be the main source of content in mathematics lessons, with the majority of instruction occurring from the front, followed by the rehearsal of methods in numerous exercises. HMI inspections have shown that teachers are essentially cautious and conservative (Bolton, 1992) and various forms of evidence indicate that these descriptions can be more accurately applied to teachers of mathematics than any other subject group. All of this leads to the conclusion that if mathematical performance is lower than that of other subjects, this is more likely to be due to the traditionalism than the progressivism of mathematics teachers.

The various findings of this study offer a very bleak view of the learning of the students at Amber Hill, but the research evidence reviewed above suggests that there was nothing unusual about the Amber Hill approach. In my observations of mathematics classrooms over the last ten years I would say that the Amber Hill teachers were fairly typical in the way that they presented mathematics. Jaworski (1994) also notes that in twelve years of teaching mathematics in different parts of this country the 'exposition and practice' approach (Jaworski, 1994, p8) was the most common. If the Amber Hill teachers were particularly unusual, it would seem unlikely that all eight of the teachers in the department would share the same 'unusual' characteristics, yet the eight different mathematics teachers, who varied in popularity and experience, prompted the same set of responses from students. The only distinctive feature that I noted at Amber Hill was the tendency of the teachers to make mathematics even more closed and rule bound because of the working class nature of the students. This tendency to move mathematics into a closed domain served to demonstrate even more clearly the implications of a back-to-basics approach for the mathematical learning of students.

11.4.6 The impact of the GCSE examination

The findings of this study should also prompt consideration of the value of the examination system and the knowledge assessed within it in this country. At Phoenix Park the school was successful in giving students a broad perspective on mathematics, and the students had become open, flexible thinkers. All this changed when they reached Christmas of year 11 and they started examination preparation. At this time they narrowed their view of mathematics, they formed the opinion that the mathematical procedures they learned were confusing and irrelevant and they constructed barriers or boundaries between the mathematical knowledge of the classroom and the mathematical demands of their jobs and lives. Lerman (1990) states that new forms of learning require new forms of assessment and it was obvious that the Phoenix Park students were disadvantaged by an examination system that was incompatible with their school's approach, even though they attained higher grades than the Amber Hill students. More generally, the demands upon all teachers to prepare students for an examination that assesses mathematical methods and procedures, in narrow and closed questions, diminishes the potential for teachers to move away from a narrow and closed teaching model and reduces the likelihood of their spending time letting students explore and use mathematics in open or authentic situations.

Prior to the start of my research study Phoenix Park was involved in a pilot of a new examination that combined open and closed questions, in order to assess mathematical process as well as content. In 1994 the School Curriculum and Assessment Authority withdrew this new form of GCSE examination. The next cohort of Phoenix Park students was required to take the more traditional content based examination. The proportion of students attaining grades A-C and A-G shifted from 32% and 97% respectively in 1993 to 12% and 84% in 1994. In the summer following the end of my 3-year research project Phoenix Park was inspected by OFSTED. In anticipation of this inspection and the need to increase GCSE grades, the head teacher at Phoenix Park forced the mathematics department to end their project-based approach and teach from textbooks. In response to the new middle class parents putting pressure upon the school, Phoenix Park also started to set students for mathematics. The teachers in the mathematics department responded badly to these changes with feelings of demoralisation and disempowerment. Jim Cresswell was convinced that the students were being disadvantaged in many ways and that the changes would not increase examination performance, particularly for students in low set groups who, he reported had become disaffected. Jim believed that he was ineffective as a textbook teacher and he resigned from teaching in response to these changes. Significantly, he believed that there was no place for an open, authentic approach to mathematics education within the current 'back to basics' political climate.

11.5 Implications for the Future

The students who left Amber Hill and Phoenix Park at the end of my research had developed very different capabilities and understandings as a result of their school training. At Amber Hill many of the students were submissive, unlikely to think mathematically in situations they would encounter and generally disillusioned by their mathematical experiences. At Phoenix Park many of the students were confident, they liked to use their initiative and they were flexible in their use of mathematics. These responses can be related back to the mathematical and whole school approaches they experienced. Phoenix Park's mathematics department has now moved a long way towards the Amber Hill model of teaching and there is evidence that many schools are returning to policies of setting and textbook teaching in response to government initiatives. Perhaps the most worrying result of this trend is that there no longer seems to be a place in education for teachers who want to innovate or try new approaches and for teachers who strive towards something more than examination training. Jim was forced to leave teaching because he did not know of any school in existence that taught mathematics using an open approach, despite the enormous wealth of research evidence, spanning back over 60 years or more, that has shown the advantages of these approaches (Benezet, 1935a, 1935b, 1936; Charles & Lester, 1984; Baird & Northfield, 1992; Cobb, Wood, Yackel & Perlwitz, 1992). Schools now have to teach the same curriculum and most of them have adopted the same traditional pedagogy and practice, because they believe that this is what is required by the national curriculum and the examination system. Phoenix Park's open, project-based approach has been eliminated and there is a real possibility that the students who left the school in 1995 as active mathematical thinkers will soon be replaced by students of mathematics who are submissive and rule bound and who see no use for the methods, facts, rules and procedures they learn in their school mathematics lessons:

> Sue: If we do use maths outside of school it's got the same atmosphere as how it used to be, but not now.
> JB: What do you mean by it's got the same atmosphere?
> Sue: Well, when we used to do projects, it was like that, looking at things and working them out, solving them - so it was similar to that, but it's not similar to this stuff now, it's, you don't know what this stuff is for really, except the exam. (Sue, Phoenix Park, year 11)

References

Abraham, J (1994). Positivism, Structurationism and the Differentiation - Polarisation Theory: a reconsideration of Shilling's novelty and primacy thesis. *British Journal of Sociology of Education,* 15(2), 231-241.

Abraham, J (1995). *Divide and School: Gender and Class dynamics in comprehensive education*. London: Falmer Press.

Adey, P; Fairbrother, R; Johnson, B & Jones, C (1995). *A Review of Research Related to Learning Styles and Strategies* . Unpublished report prepared for OFSTED. London: OFSTED.

Agar, M (1986). *Speaking of Ethnography*. London: Sage.

Ames, C; Ames, R & Felker, D W (1977). Effects of competitive reward structure and valence of outcome on children's achievement attributions. *Journal of Educational Psychology,* 69, 1-8.

Ames, C (1984). Achievement attributions and self-instructions under competitive and individualistic goal structures. *Journal of Educational Psychology,* 76, 478-487.

Anyon, J (1980). Social class and the hidden curriculum of work. *Journal of Education,* 162(1), 67-92.

Anyon, J (1981). Schools as agencies of social legitimation. *International Journal of Political Education,* 4(3), 195-218.

Askew, M & Wiliam, D (1995) *Recent Research in Mathematics Education 5 - 16* London: HMSO

Athappilly, K; Smidchens, U & Kofel, J (1983). A Computer-based Meta-analysis of the Effects of Modern Mathematics in Comparison with Traditional Mathematics. *Education Evaluation and Policy Analysis,* 5(4), 485-493.

Baird, J R & Northfield, J R (Eds.). (1992). *Learning from the PEEL experience.* Melbourne: Monash University.

Ball, S J (1981). *Beachside comprehensive.* Cambridge: Cambridge University Press.

Ball, S J (1987) *The Micro-Politics of the School* Methuen: London

Ball, S J (1993). Education, Majorism and the 'curriculum of the dead'. *Curriculum Studies,* 1(2), 195-214.

Ball, S J (1994). Culture, Crisis and Morality: The Struggle Over the National Curriculum. In P. Atkinson, S. Delamont, & W. B. Davies (Eds.), *Discourse and Reproduction: A Festschrift for Basil Bernstein* pp. 85-102. Cresskill, New Jersey: Hampton Press.

Ball, S J (1996). Intellectuals or Technicians? The urgent role of theory in educational studies. *British Journal of Educational Studies,* 255-271.

Bassford, D (1988). *Fractions: A Comparison of Teaching Methods.* Nottingham: Shell Centre, University of Nottingham.

Barnes, D; Britton, J; Rosen, H & the London Association of Teachers of English (1969). *Language, the learner and the school.* Middlesex: Penguin.

Becker, J R (1995). Women's Ways of Knowing in Mathematics. In P. Rogers & G. Kaiser (Eds.), *Equity in Mathematics Education: Influences of Feminism and Culture* pp. 163-174. London: Falmer Press.

Bell, A W (1993). Some experiments in diagnostic teaching. *Educational Studies in Mathematics,* 24(1), 115-137.

Benezet, L P (1935a). The Teaching of Arithmetic I; The Story of an Experiment. *Journal of the National Education Association,* November 1935, 241-244.

Benezet, L P (1935b). The Teaching of Arithmetic II; The Story of an Experiment. *Journal of the National Education Association,* December 1935, 301-303.

Benezet, L P (1936). The Teaching of Arithmetic III; The Story of an Experiment. *Journal of the National Education Association,* December 1936, 241-244.

Bernstein, B (1966) Sources of consensus and disaffection in education *Journal of the Association of Assistant Mistresses* 17 (1) 4-11.

Bernstein, B (1971). On the Classification and Framing of Educational Knowledge. In M. F. D. Young (Ed.) *Knowledge and Control* pp. 47-69. London: Butler and Tanner.

Bernstein, B (1975). Class and pedagogies: visible and invisible. In B. Bernstein (Ed.) *Class, codes and control volume 3: towards a theory of educational transmissions* pp. 116 - 145. London, UK: Routledge and Kegan Paul.

Beynon, J (1985). *Initial encounters in the secondary school.* London: Falmer.

Bliss, J; Monk, M & Ogborn, J (1983). *Qualitative data analysis for educational research: a guide to the use of systemic networks.* London, UK: Croom Helm.

Blum, W & Niss, M (1991). Applied Mathematical Problem Solving, Modelling, Applications and Links to other subjects - State, Trends and Issues in Mathematics Instruction. *Educational Studies in Mathematics,* 11(1), 37 - 69.

Bolton, E (1992). The Quality of Teaching. In *Education - Putting the Record Straight* Stafford UK: Network Press.

Bourne, J & Moon, B (1994). A question of ability? In B. Moon & A. Mayes (Eds.), *Teaching and Learning in the Secondary School* (pp. 25-37). London: Routledge.

Brousseau, G (1984). The Crucial Role of the Didactical Contract in the Analysis and Construction of Situations in Teaching and Learning Mathematics. In H. G. Steiner (Ed.) *Theory of Mathematics Education* pp. 110-119. Bielefeld Germany: Institut für Didactik der Mathematik der Universität Bielefeld.

Brown, J; Collins, A & Duguid, P (1989). Situated Cognition and the Culture of Learning. *Educational Researcher,* 32-42.

Bryk, S; Lee, V & Holland, P (1993). *Catholic Schools and the Common Good.* London: Harvard University Press.

Bryman, A (1988). *Quantity and Quality in Social Research.* London: Unwin, Hyman.

Burgess, R (1988). In the Company of Teachers: Key Informants and the Study of a Comprehensive School. In R. Burgess (Ed.) *Strategies of Educational Research: Qualitative Methods* Lewes: Falmer.

Burton, L (1986a). Femmes et Mathematiques: y-a-ul une intersection? Paper presented to the *Femmes et Mathematiques*, Conference Quebec: Canada.

Burton, L (1986b) (ed) *Girls Into Maths Can Go* Eastbourne: Holt, Rinehart.

Burton, L (1995). Moving Towards a Feminist Epistemology of Mathematics. In P. Rogers & G. Kaiser (Eds.), *Equity in Mathematics Education: Influences of Feminism and Culture* pp. 209-226. London: Falmer Press.

Buxton, L (1981). *Do you panic about maths?: coping with maths anxiety*. London, UK: Heinemann Educational Books.

Charles, R & Lester Jr, F (1984). An evaluation of a process-oriented instructional program in mathematical problem solving in grades 5 and 7. *Journal for Research in Mathematics Education*, 15(1), 15-34.

Cheek, H & Castle, K (1981). The Effects of Back-to-Basics on Mathematics Education. *Contemporary Educational Psychology*, 6, 263-277.

Cobb, P (1986). Contexts, Goals, Belief and Learning Mathematics. *For the Learning of Mathematics*, 6(2), 2-10.

Cobb, P; Wood, T; Yackel, E; Nicholls, J; Wheatley, G; Trigatti, B & Perlwitz, M (1991). Assessment of a Problem-Centered Second-Grade Mathematics Project. *Journal for Research in Mathematics Education*, 22(1), 3-29.

Cobb, P; Wood, T; Yackel, E & Perlwitz, M (1992). A Follow-Up Assessment of a Second-Grade Problem-Centered Mathematics Project. *Educational Studies in Mathematics*, 23, 483-504.

Cockcroft, W H (1982). *Mathematics Counts: Report of Inquiry into the Teaching of Mathematics in Schools*. London: HMSO.

Cognition and Technology Group at Vanderbilt (1990). Anchored Instruction and its Relationship to Situated Cognition. *Educational Researcher*, 19(6), 2-10.

Cohen, L & Manion, L (1990). *Research Methods in Education*. London: Routledge.

Corrigan, P (1979). *Schooling the Smash Street Kids*. Basingstoke: MacMillan.

Dahllöf, U (1971). *Ability grouping, content validity and curriculum process analysis.* New York: Teachers College Press.

Dar, Y & Resh, N (1986). *Classroom Composition and Pupil Achievement.* New York: Gordon and Breach.

Davis, R B (1992). Reflections on where mathematics education now stands and on where it may be going. In D. A. Grouws (Ed.) *Handbook of Research on Mathematics teaching and learning* pp. 724-734. New York: MacMillan.

Delamont, S (1984). The Old Girl Network: Reflections on the Fieldwork at St Luke's. In R. Burgess (Ed.) *The Research Process in Educational Settings: Ten Case Studies* London: Falmer.

Department for Education and Science (1989). *Mathematics in the national curriculum.* London: HMSO.

Department for Education and Science (1991). *Mathematics in the national curriculum.* London: HMSO.

Department for Education (1993). *DFE News 16/93 Improving Primary Education - Patten.* London: DFE.

Diener, C I & Dweck, C S (1978). An analysis of learned helplessness: continous changes in performance, strategy and achievement cognitions following failure. *Journal of Personality and Social Psychology,* 36, 451-462.

Dowling, P & Noss, R (Eds.). (1990). *Mathematics versus the national curriculum.* London: Falmer.

Doyle, W (1983). Academic work. *Review of Educational Research,* 53(2), 159-199.

Doyle, W & Carter, K (1984). Academic Tasks in Classrooms. *Curriculum Enquiry,* 14, 129-149.

Doyle, W (1988). Work in Mathematics Classes: The Context of Students' Thinking During Instruction. *Educational Psychologist,* 23(2), 167-180.

Dweck, C S (1986). Motivational processes affecting learning. *American Psychologist (Special Issue: Psychological science and education)*, 41(10), 1040-1048.

Eisenhart, M (1988). The Ethnographic Research Tradition and Mathematics Education Research. *Journal for Research in Mathematics Education*, 19(2), 99-114.

Elwood, J; Hayden, M; Mason, K; Stobart, G; White, J (1992) *Differential Performance in Examinations at 16+: English and Mathematics* London: SEAC.

Ely, M (1991). *Doing Qualitative Research: Circles within circles*. London: Falmer.

Erlwanger, S H (1975). Case Studies of Children's Conceptions of Mathematics Part 1. *Journal of Children's mathematical behaviour*, 1(3), 157 - 283.

Fennema, E & Sherman, J (1977). Sex-related differences in mathematics achievement: spatial visualization and affective factors. *American Educational Research Journal*, 14, 51-71.

Fennema, E & Sherman, J (1978). Sex-related differences in mathematics achievement and related factors: A further study. *Journal for Research in Mathematics Education*, 9, 189-203.

Finch, J (1984). "It's great to have someone to talk to": the ethics and politics of interviewing women. In C. Bell & H. Roberts (Eds.), *Social Researching* London: Routledge.

Fletcher, C; Caron, M & Williams, W (1985). *Schools on Trial: The Trials of Democratic Comprehensives*. Milton Keynes: OU Press.

Gewirtz, S; Ball, S & Bowe, R (1993). Values and Ethics in the Education Market Place: the case of Northwark Park. *International Studies in Sociology of Education*, 3(2), 233-254.

Gewirtz, S; Ball, S & Bowe, R (1995). *Markets, Choice and Equity in Education*. Buckingham: Open University Press.

Gibson, J J (1986). *The ecological approach to visual perception*. Hillsdale NJ: Lawrence Erlbaum.

Gilligan, C (1982). *In a Different Voice: Psychological Theory and Women's Development.* Cambridge, Massachusetts: Harvard University Press.

Glaser, B G & Strauss, A L (1967). *The discovery of grounded theory: strategies for qualitative research.* New York, NY: Aldine Publishing Company.

Goffman, E (1959). *The Presentation of Self in Everyday Life.* London: Penguin.

Graded Assessment in Mathematics (1988). *GAIM Development Pack.* London: MacMillan.

Greeno, J; Smith, D & Moore, J (1993). Transfer of Situated Learning. In D. Detterman & R. Sternberg (Eds.), *Transfer on Trial* pp. 99-167. Norwood, New Jersey: Ablex Publishing Corporation.

Guba, E & Lincoln, Y (1989). *Fourth Generation Evaluation.* Newbury Park, CA: Sage.

Hammersley, M (1992). *What's wrong with Ethnography?: Methodological Explorations.* London: Routledge.

Hargreaves, D (1967). *Social Relations in a Secondary School.* London: Routledge & Kegan Paul.

Hart, L E (1989). Classroom processes, sex of student, and confidence in learning mathematics. *Journal for Research in Mathematics Education,* 20(3), 242-260.

Head, J (1995). Gender Identity and Cognitive Style. Paper presented at UNESCO / ULIE Colloquium *Is There a pedagogy for Girls?* London:UNESCO.

Hennessy, S (1993). Situated Cognition and Cognitive Apprenticeship. *Studies in Science Education,* 22, 1-41.

Her Majesty's Inspectorate (1985). *Mathematics from 5 to 16.* London: HMSO.

Her Majesty's Inspectorate (1992). *Mathematics Key Stages 1, 2 and 3.* London: HMSO.

Hiebert, J (1986). *Conceptual and Procedural Knowledge: The Case of Mathematics.* New Jersey: Lawrence Erlbaum.

Hiebert, J & Carpenter, T (1992). Learning and Teaching with Understanding. In D. A. Grouws (Ed.) *Handbook of Research on Mathematics Teaching and Learning* pp. 65-100. New York: MacMillan.

Holt, J (1967). *How Children Learn*. Middlesex: Penguin.

Huberman, A M & Crandall, D P (1982). Fitting Words to Numbers. *American Behavioural Scientist* 26 (1), 62-83

Jackson, B (1964). *Streaming: An Education System in Miniature*. London: Routledge & Kegan Paul.

Jaworski, B (1994). *Investigating Mathematics Teaching: A Constructivist Enquiry*. London: Falmer Press.

Jick, T D (1983). Mixing Qualitative and Quantitative Methods: Triangulation in Action. In J. Van Maanen (Ed.) *Qualitative Methodology* Newbury Park, California: Sage.

Johnston, B (1995). Mathematics: An Abstracted Discourse. In P. Rogers & G. Kaiser (Eds.), *Equity in Mathematics Education: Influences of Feminism and Culture* pp. 226-234. London: Falmer Press.

Kaisser-Messmer, G & Rogers, P (1994). Gender and mathematics education. In C. Gaulin, B. R. Hodgson, D. H. Wheeler, & J. C. Egsgard (Eds), *Proceedings of the 7th International Congress on Mathematical Education* pp. 28-37. Sainte-Foy: Les Presses de L'Université Laval.

Keddie, N (1971). Classroom knowledge. In M. F. D. Young (Ed.) *Knowledge and control* pp. 133-160. London, UK: Collier-Macmillan.

Keedy, J & Drmacich, D (1994). The Collaborative Curriculum at the School Without Walls: Empowering Students for Classroom Learning. *The Urban Review*, 26(2), 121-135.

Kluckhohn, F (1940). The participant observation technique in small communities. *American Journal of Sociology*, 46(3), 331-43.

Lacey, C (1970). *Hightown Grammar*. Manchester: Manchester University Press.

Lampert, M (1986). Knowing, doing and teaching multiplication. *Cognition and Instruction,* 3, 305-342.

Lave, J & Reed, H J (1981). Arithmetic as a tool for investigating relations between cultur and cognition. In R. Casson, W (Ed.) *Language, Culture and Cognition: Anthropological Perspectives* New York: Macmillan.

Lave, J (1982). A comparative approach to educational forms and learning processes. *Anthropology and Education Quarterly,* 8(3), 181-187.

Lave, J; Murtaugh, M & de la Rocha, O (1984). The dialectical construction of arithmetic practice. In B. Rogoff & L. J (Eds.), *Everyday Cognition: It's Development in Social Context* pp. 67-97. Cambridge MA: Harvard University Press.

Lave, J (1986). Experiments, tests, jobs and chores: how we learn what to do. In K. Borman & J. Reisman (Eds.), *Becoming a worker* Norwood NJ: Ablex.

Lave, J (1988). *Cognition in practice.* Cambridge: Cambridge University Press.

Lave, J & Wenger, E (1991). *Situated Learning: legitimate peripheral participation.* New York: Cambridge University Press.

Lave, J (1993). Situating Learning in Communities of Practice. In L. Resnick, J. Levine, & T Teasley (Eds.), *Perspectives on Socially Shared Cognition* pp. 63-85. Washington: American Psychological Association.

Lave, J (1996a) *Situated cognition in mathematics.* Seminar held at Oxford University, Department of Educational Studies, 3 May 1996.

Lave, J (1996b) *Personal Communication*

Leacock, E, B (1969). *Teaching and Learning in City Schools.* New York: Basic Books

Leder, G (1990). Gender differences in mathematics: An overview. In E. Fennema & G. Leder (Eds.), *Mathematics and Gender* pp. 10-26. New York: Teachers College Press.

Leont'ev, A N (1981). The problem of activity in psychology. In J. V. Wertsch (Ed.) *The concept of activity in Soviet psychology* Armonk NY: M. E. Sharpe.

Lerman, S (1990). Alternative Perspectives of the Nature of Mathematics and Their Influence on the Teaching of Mathematics. *British Educational Research Journal,* 16 1), 53-61.

London Mathematical Society; Institute of Mathematics and its Applications & Royal Statistical Society (1995). *Tacking the Mathematics Problem.* London: London Mathematical Society.

Louis, K S (1982). Multimethod Studies. Americal Behavioural Scientist 26(1), 6-22.

Lundgren, U P (1977) *Model Analysis of Pedagogical Processes* CWK: Gleerup.

Maher, C (1991). Is dealing with mathematics as a thoughtful subject compatable with maintaining satisfactory test scores? A nine-year study. *Journal of Mathematical Behaviour,* 10, 225-248.

Masingila, J (1993). Learning from Mathematics Practice in Out-of-School Situations. *for the learning of Mathematics,* 13(2), 18-22.

Mason, J (1989) Mathematical Abstraction as the result of a Delicate Shift of Attention *for the Learning of Mathematics* 9 (2), 2-9

Measor, L (1985). Interviewing: A Strategy in Qualitative Research. In R. Burgess (Ed.) *Strategies of Educational Research: Qualitative Methods* Sussex: Falmer.

Miles, M B (1982). A Mini Cross Site Analysis (Commentary on other studies). *Americal Behavioural Scientist,* 26 (1), 121-132.

Mura, R (1995). Feminism and Strategies for Redressing Gender Imbalance in Mathematics. In P. Rogers & G. Kaiser (Eds.), *Equity in Mathematics Education: Influences of Feminism and Culture* (pp. 155-162). London: Falmer Press.

National Council for Teachers of Mathematics (1989). *Curriculum and Education Standards for School Mathematics.* Virginia: NCTM.

National Curriculum Council (1993). *The National Curriculum at Key Stages 1 and 2: Advice to the Secretary of State for Education.* York: NCC.

Neill, A S (1985). *Summerhill.* Middlesex: Penguin.

Noss, R (1991). The social shaping of computing in mathematics education. In D. Pimm & E. Love (Eds.), *Teaching and Learning School Mathematics* pp. 205-219. London: Hodder & Stoughton.

Noss, R (1994). Structure and Ideology in the Mathematics Curriculum. *For the Learning of Mathematics,* 14(1), 2-11.

Nunes, T; Schliemann, A D & Carraher, D W (1993). *Street Mathematics and School Mathematics.* New York: Cambridge University Press.

Office of Population Censuses & Surveys (1980). *Classification of Occupations 1980* London:HMSO

Panorama (1996) *Hard Lessons,* BBC1 3/6/96

Perry, M (1991) Learning and Transfer: Instructional Conditions and Conceptual Change. *Cognitive Development,* 6(4), 449-468.

Peterson, P L & Swing, S R (1982). Beyond Time on Task: Students' Reports of Their Thought Processes During Classroom Instruction. *The Elementary School Journal,* 82(5), 481-491.

Peterson, P; Swing, S; Stark, K & Waas, G (1984). Students' Cognitions and Time on Task During Mathematics Instruction. *American Educational Research Journal,* 21 (3), 487-515

Peterson, P & Fennema, E (1985). Effective teaching, student engagement in classroom activities and sex-related differences in learning mathematics. *Americal Educational Research Journal,* 22(3), 309-335.

Peterson, P (1988). Teaching for Higher Order Thinking in Mathematics: The Challenge for the Next Decade. In D. Grouws & T. Cooney (Eds.), *Effective Mathematics Teaching* pp. 2-26. Reston Virginia: Lawrence Erlbaum.

Resnick, L (1990). From protoquantities to number sense. In G. Booker, P. Cobb, & M. T Mendicuti (Eds.), *Proceedings: Fourteenth PME Conference* pp. 305-311. Mexico: the Program Committee.

Resnick, L B (1993). Shared Cognition: Thinking as Social Practice. In L. B. Resnick, J. M. Levine, & S. D. Teasley (Eds.), *Perspectives on Socially Shared Cognition* (pp. 1-22). Washington, DC: American Psychological Association.

Resnick, L; Levine, J & Teasley, S (Eds.). (1993). *Perspectives on Socially Shared Cognition*. Washington DC: American Psychological Association.

Riding, R & Douglas, G (1993). The Effect of Cognitive Style and Mode of Presentation on Learning Performance. *British Journal of Educational Psychology*, 63, 297-307.

Rogers, P & Kaiser, G (Eds.). (1995). *Equity in Mathematics Education: Influences of Feminism and Culture*. London: Falmer Press.

Romberg, T A & Carpenter, T A (1986). Research on teaching and learning mathematics: two disciplines of scientific inquiry. In M. C. Wittrock (Ed.) *Handbook of research on teaching* (pp. 850-873). New York: Macmillan.

Rosenbaum, J E (1976). *Making Inequality: The hidden curriculum of high school tracking*. New York: Wiley.

Rosenthal, R & Jacobson, L (1968). *Pygmalion in the classroom*. New York: Holt, Rinehart & Winston.

Rosenthal, R (1974). *On the social psychology of the self-fulfilling prophecy: Further evidence for Pygmalion effects and their mediating mechanisms*. New York: MSS Modular Publications.

Schoenfeld, A H (1985). *Mathematical Problem Solving*. New York: Academic.

Schoenfeld, A H (1988). When good teaching leads to bad results: the disasters of "well-taught" mathematics courses. *Educational Psychologist*, 23(2), 145-166.

Schoenfeld, A (1992). Learning to Think Mathematically: Problem Solving, Metacognition, and Sense Making in Mathematics. In D. A. Grouws (Ed.) *Handbook of Research on Mathematics Teaching and Learning* pp. 334-371. New York: MacMillan.

Secada, W G; Fennema, E & Adajian, L B (Eds.) (1995). *New Directions for Equity in Mathematics Education*. New York: Cambridge University Press.

Sharp, R & Green, A (1975). *Education and Social Control: A Study in Progressive Primary Education*. Boston Mass: Routledge & Kegan Paul.

Sigurdson, S & Olson, A (1992). Teaching Mathematics with Meaning. *Journal of Mathematical Behaviour*, 11, 37-57.

Silver, E A (1994). On Mathematical Problem Posing. *For the learning of Mathematics*, 14(1), 19-28.

Silverman, D (1993). *Interpreting Qualitative Data: Methods for analysing talk, text and interaction*. London: Sage.

Siskin, L, S. (1994). *Realms of Knowledge: Academic departments in Secondary Schools*. London: Falmer Press.

Slavin, R E (1990). Achievement effects of ability grouping in secondary schools: a best evidence synthesis. *Review of Educational Research*, 60 (3), 471-499.

Smith, A G & Robbins, A E (1982). Structured Ethnography. *Americal Behavioural Scientist* 26 (1), 45-61

Strauss, A & Corbin, J (1990). *Basics of Qualitative Research: Grounded Theory Procedures and Techniques*. California: Sage.

The Guardian (8/6/96). *Blair rejects mixed ability teaching*, page 7.

Times Educational Supplement (14/6/96) *Don't give idealsim a bad name* page 7.

Tobias, S (1978). *Overcoming Math Anxiety*. New York: Norton.

Tomlinson, S (1987). Curriculum option choices in multi-ethnic schools. In B. Troyna (Ed. *Racial Inequality in Education* pp. 92-108. London: Tavistock.

Treffers, A (1987). *Three dimensions: a model of goal and theory description in mathematics instruction - the Wiskobas project*. Dordrecht, Netherlands: Kluwer.

Vygotsky, L S (1978). *Mind in Society:The Development of Higher Psychological Processes*. Cambridge, MA: Harvard University Press.

Walker, R & Adelman, C (1975). *A guide to classroom observation*. London: Methuen.

Whitehead, A N (1962). *The Aims of Education*. London: Ernest Benn.

Willis, P (1977). *Learning to Labor*. New York: Columbia University Press.

Willis, S (1995). Gender Reform through School Mathematics. In P. Rogers & G. Kaiser (Eds.)*Equity in Mathematics Education: Influences of Feminism and Culture* pp. 186-199. London: Falmer Press.

Wood, D; Bruner, J & Ross, G (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry*, 17, 89-100.

Young, M F (1993). Instructional Design for Situated Learning. *Educational Technology, Research and Development*, 41(1), 43-58.

Appendix 1: Papers accepted for publication

Boaler, J (1996) Learning to lose in the mathematics classroom: a critique of traditional schooling practices in the UK. *Qualitative Studies in Education* 9 (1) 17 - 33 [based on findings presented in chapters 4 and 6]

Boaler, J (1996) When even the winners are losers: evaluating the experiences of 'top set' students. *Journal of Curriculum Studies (in press)* [based on findings presented in chapters 9 and 10]

Boaler, J (1996) Applications or Algorithms? Case studies of alternative approaches to teaching. *Journal of Research in Mathematics Education (in press)* [based on findings presented in chapters 4 - 8]

Boaler, J (1996) Reclaiming school mathematics: the girls fight back. *Gender and Education (in press)* [based on findings presented in chapter 9]

Appendix 2 An example of a coded interview

Amber Hill, year 11, set 3, Sara & Lola

JB OK can you start off by telling me what you normally do in maths lessons or what you have done ~~over the~~ years?
var S I dunno, usually it's just textbooks innit?
L Yes.
S Then there's R plus which is a new book - revision.
exam L Things we're supposed to have in the exam - this year's really just been working up to our exam, going over things we'll need in the exam.
S Doing past papers, mocks and things - working through 'em and seeing how we can improve.
L And orals.
S Orals yeh.
L Practice orals.
JB So, until a few months ago it was textbooks?
var S No, until a few weeks ago it was all textbooks - then we started to do general reviews from the back of the books, to see how we'd manage with them, then we started to do this stuff.
JB ~~And~~ what do you think about maths lessons?
bor S Boring - I don't mind when she says, oh go up to so-and-so and we can just get on with it - ~~we usu~~ally ignore her don't we? - don't like the lectures. dir own
L Yeh the lectures.
var S They go on for ages.
L But, some of ~~them mak~~e sense - if you can be bothered to listen to them for half an hour, three quarters of an hour, ~~but,~~ you can listen to them for about ten minutes and ~~then you~~ get bored. var dir
off S You tune out.
L Yeh, ~~start~~ writing in your book things like that.
S If it was shorter, plus, she does about...
own L We do it on our own don't we? (laughs) var, dir
own S Yeh, she goes on for about three quarters of an hour telling us how to do it and we've done about 6 questions before she's ~~finished telling us~~ what to do.
L Yeh, we've already done it - if we do it on our own we do it, and she does it and gets it right, but we've done it two completely ~~different~~ ways - we've done it the short way and she's done it like, I suppose because you need more working out, but we both get the same answer.
an JB And is that alright?
S Yeh I prefer it that way because I remember it more.
JB Does it matter that you've used a ~~different~~ method?
S Well if you get to the same answer it shouldn't.
mtm L You ~~have to ha~~ve method, it can't just be that you put the answer - but she just seems to write - *loads* of method and you think - oh my God! anx
S You can't remember that much, no matter how much you look at it, you can't remember this whole page of method, when you can do it easily.
JB If she is going through it on the board and you can do it in a few minutes, why does she take so long on the board - what is she doing?
sets L It's probably because some people don't get it, so she has to make sure everyone gets it, but we can't just listen to it for ages.
off S We sit and write in our books!
JB So she's going over ~~how to~~ do it?
L Yeh.
S Sometimes she says oh all right then, she like stands there and she gives out a question and she's waiting and suddenly everyone realises she wants you to answer - and no-one's
off

)ff listened to the question, and everyone's looking away and you're going oh yeh and no-one can answer it.

JB When people aren't working in a lesson - say when she's talking and you're not listening, what are people doing? are they just sitting there? - or what?

S Writing messages.

L I always write in my book - if you see my maths book...

bor S It's full of graffitti!

L It's just because I get bored so I just write on my book.

JB It's just, you all look really well behaved, as though you're all working quietly.

L Yeh we are well behaved at the same time!

con S Yeh writing messages! - quietly.

dis L I didn't used to be - I used to get kicked out every lesson, but I was out of order.

S Yeh, most of the time.

JB So do you think when people aren't listening they just sit and write in their books and are quiet?

S Basically.

;, con L We are a well behaved class though - because it's our head of year.

not S Yeh that's the only reason why.

con L It's our head of year so everyone wants to stay in her good books.

e S Not because everyone loves maths or anything.

JB What did you think about the booklets you used in the first two years here?

S I thought they were good.

ace L I dunno if the booklets were good - or if it was working at your own pace.

S Yeh, like now, I've got a little sister whose doing them now, and I look at the booklets

und and I don't know how to do them, but as you get more advanced you know how to do the

und really hard stuff like pythagoras, but you go back to doing like the second year work and you look at it and you're thinking...

int S What's that?

mean L Yeh, like long multiplication and all that stuff - you're thinking uh? mean

S Yeh, like the orals - we didn't know how to work it out.

JB So you like going at your own pace?

S Yes definitely.

pace L Yes, but It's not like we go slow if we go at our own pace, it's not that we go slow, we don't think oh going at our own pace, lets do one sum a lesson type of thing.

und S It's good, because you know if you understand something you can move on.

L And if you don't you can spend more time on it. You spend more time on it - but she wants

? to move on, so you just leave that bit and go onto the next bit even though you don't know the bit before and the whole chapter is like, you just don't know what's going on. und

lean S You don't know what it is, let alone learn it.

JB OK What about the coursework, what did you think of that?

pen L I liked that.

S Yeh I liked that.

L It was good - but we done it together. group

S We worked together.

L Yeh and we done good on all of them - I got about eight and a half on the last one, out of

pace ten which is really good - but that was because we was working at our own pace, again, because it's an open ended task. We just had a deadline but we could just do whatever we own

own wanted, so it was just up to us, she helped us but she wasn't allowed to help us too much

think S She could like, what's the word? make us think, say things to make us think, but she couldn't actually say - you could do this, so we was helped, but, she didn't tell us what to

own do, she'd give us the idea and we had to work it out, it was good.

JB Why did you think that was good?

rem S Yeh 'cause I can still remember how we worked everything out and I can use them like in

y other things.

L Yeh it was good.

JB Why is that, that you can use it in other things?

L It was a project, so it was going from one little thing and getting this big result at the end - working through on your own, going through different stages I was really proud of it actually, it was good.
S We was dead chuffed weren't we?
JB How is that different from working through books?
L Well we *have to*, I suppose we *have to* work from the books.
S Some questions are stupid aren't they? about bits of wire and pendulums just pointless
L And it's so easy to forget, because you're just working through 'em, you go from one bit to the next bit. So you go from like, doing trigonmetry, to doing long multiplication or algebra, and then you do this and you do that, and you get the general drift of all of it, but...
S You can't do it in the exam.
L You feel more proud of the projects when you done them yourself, if it's just working through the book, you can't feel proud - well, you can get them right and nobody cares - like you've seen it, it doesn't really matter, but if it's like a big project and you can see like what mark you've got at the end and if you've worked hard and if you get a good mark you feel really good about it.
S Yeh.
JB OK, can you think of a maths lesson that you've really enjoyed, one that stands out for you?
S Coursework.
L Yeh the coursework - the open ended task I think.
JB Uh huh, and besides the open ended tasks, are there any others?
S (Sighs) No, they're all the same the others.
L They're all sort of the same, just the same thing.
JB What about ones that you really haven't liked, are there any?
L No, 'cause they're the same ones, they're all the same.
S Nothing changes.
JB How does maths compare to other subjects at the school - is it similar to anything else?
S It's quite similar to science - learning formula's but I suppose that's the only thing that's similar - it's not really like anything else - I don't think there are any other lessons when we sit and do work from textbooks, except for science.
L Yeh, there are lessons when we work with textbooks, but not all the time, say like one lesson a week, but not all the time, we watch videos or have discussions, but in maths it's just the textbooks.
JB What do you do the rest of the time in other subjects when you're not working from textbooks?
L We watch videos, do practical things, have debates - in English, go through different books, write stories.
S It's a better way to learn but I think it's different from maths because in maths you have to use books, type of thing, they all do, don't they, all schools, I think they do don't they?
JB Not all schools do - some schools use individualised booklets where you work at your own pace, all of the time and some schools do more projects - like your coursework projects but all of the time.
S That sounds good.
L Yeh, it does sound good.
JB But you're right most schools use textbooks.
L Yeh I suppose you just get used to doing textbooks in maths.
S Still, if I had a choice I'd rather do it a different way - it's just so *boring* five years doing textbooks.
JB OK, if you were doing a problem in your books and you couldn't do it, at all, what do you do?
S Well, I suppose we wait until the answer's given out and write it in.
L Yeh sometimes we ask her for help and she tells us how to do it - she does *try* and make us understand it.
JB And do you understand when she tells you?
L Some of the time but other times not really.
JB And why don't you when you don't?

L I dunno, if she's not busy then she comes and helps you - but I suppose you've got to help other people if they don't get it, but if loads of people can't do the same one then she does it on the board, which you usually can understand but she does it...

und

S Long.

L She does it the long way - I suppose if you listen then you get it, but if you don't listen because you're bored then you don't get it so I suppose it's just like whether we're listening or not.

off

S And then you ask her and she tells you a bit of it but because you weren't listening then you don't understand it.

L But I suppose if I listen to her when she's talking then I understand it but when I don't then I don't - which I suppose is what's going to happen.

S Yeh. (both laugh)

JB OK, is maths the sort of subject when you have to be self-disciplined, self-motivated to get on with the work, or does the teacher keep you going?

S No, I think you have to want to do it or else you don't listen and you don't do it.

off

L Then again, I never used to want to do maths though.

S No, but we've improved now.

L Yeh we've improved but I reckon, if I had another teacher like say Miss Thompson or... If I had had other teachers that ain't as strict as Miss Neville I would never have done it, I know I would never have done it because I don't like maths, I know that I'm alright at maths, I can do maths but if I had the choice I wouldn't do it, but because I had miss Neville I *had* to do my homework, and I had to hand it in and if I weren't there I *had* to catch up, so if I weren't there one day I *had* to catch up otherwise, like, I would have to stay behind, so I think if I hadn't have had her I wouldn't have done it.

out mot

JB Are there any subjects where if you had a teacher that didn't make you work that you would work anyway?

L I suppose in English I work there but he's not really strict we just like him, if you like a teacher then you do it, I haven't really got a teacher that I don't like.

mot

JB Have you got subjects where you enjoy the work, so you would do it because of that?

L Yeh that's like in English, I enjoy doing the work, that's why I do it.

mot

S And dance.

JB Do you think when you use maths outside of school, in your job, or anywhere, does it feel like when you use maths in school or does it...

S No!, despite them trying to get it, and like, using fences and wire and that.

rw

L (laughs)

S That's them trying to get it into real life, but it doesn't work.

rw

JB OK, so how is it different to real life?

S Well we don't like use Pythagoras' rule or..

L Like say, well that's πr squared or...

S Yeh trigonometry. Like I work in a hairdressers and when you're like adding up the bill, that's all it is, adding up the bill, you don't think, well πr squared will give me what the customer has to pay. (laughs)

rel

L Yeh, and what's x? (laughs)

S Exactly.

L Like sometimes you read things and you think, well I am, like, outside, like outside I am never gonna have to use a Pythagoras rule or trigonometry, but the thing is you have to know it for the exam, that's what maths is like, in real life you don't need to know it but for the exam you've just got to get this grade.

rel

mod H

rel

rel

S I think in algebra you can relate it up to a point, because like the letters stand for something, like r is for ... rover (laughs) or something other than that.

und

JB And what about the things you do use in real life, like, say percentages or number work or whatever, do you think you can use that?

S Ur I dunno, I'd probably use a calculator. (laughs)

und

JB OK, and if you didn't have one, do you think you would use things you'd learned here?

S Well, I don t know how to do percentages.

L No, nor do I. (laughs)

S That's one thing I asked her to help me with, 'cause I couldn't do it in the exam. But, it still didn't make much sense.

und mean

gen

L I don't know why but I just have to know how to do things, 'cause like, I look back for revision and I've just got percentages written there and all this stuff.

und S Yeh and we don't know how to do it and it didn't make any sense, I mean, I tried doing it and I thought no, it don't make no sense. The thing is, you get the thing and you get it with

in one question, like find a percentage or something or other and you think yeh I know this

sit but then you're given another one to do and you think, oh I can't do this.

L Yeh.

sit S 'Cause the way you learned it only suits the other numbers, like high numbers or something, so it didn't make too much sense.

JB OK. How did you feel about the mocks, how did you find them?

S Some of it was really easy, but some of it was really hard.

L Yeh like really really hard.

und S I remember Miss Neville coming up to me and I said "I'm completely stuck, I just don't know what to do, I haven't got a clue!" and she was going, she just practically told me the

dir answer in the exam basically.

JB Is that because you hadn't done the stuff in the exam, or had you done it but it seemed more difficult?

S Well apparently we'd already done that stuff hadn't we?

L Yeh.

mem S But we couldn't remember it.

off L Yeh and I suppose it's different in an exam, like in class you're just going through the stuff and..

S You don't think about it.

L You're just..

nt S Like you try and make it harder than what it is, 'cause you think that's what you need to do I suppose.

JB In your exam does it seem different to how you did the work in your book or the same?

L Different.

dep S Yeh seems harder, 'cause you've got to, you haven't got a book and you know you haven't got a book and so you've got to think of it, and you think of it, but you think - but it could

int be.. and then you think of about 20 different things it could be and you've got to decide which one.

dep L 'Cause if you're in the book you can just look back and check and you can do it. Like in the exam you think oh God I can't do it.

anx JB OK, thanks. What do you think about working in sets, because you used to work in your tutor groups didn't you?

sets L Yeh, it's OK, it's like good because there's no-one that's like really behind and like no-one that like finds it really easy so you're all about the same, like you find some things really easy and some things really hard.

sets S But she like asks Nigel Moore and he knows everything and he gets it right and she goes on but no-one else knows it, but 'cause Nigel's answered it and it's on the board she goes on.

sets L Yeh that happens in every lesson, there's some-one that does that, but generally, like if she thinks some people can't do it she'll do it on the board and get people like that.

JB Uh huh and does that work OK, so that you all follow and keep up?

L Uh .. I guess so (reluctant) - sometimes.

S Depends what it is and whether you get it basically.

JB OK, when you've done something in your books, how long after do you think you can still use it - is it months? weeks?

conf

rem S (laughs) No, that's it.

L Sometimes you can do it and so you go really quick and you think Yeh! I can do it! and

model you go really quick and then 2 days later she goes...

S Yeh, in the review...

in L And you think I done that alright, and you look at it and go, I can't do it now. So like you've done it really well and you get 'em all right, but then you get to the review and you think...

nd S How did I do that?

L Yeh you think Oh God, like, how do you do that? anx

apply

sit
nt

S That's happened so many times, you just can't remember it - or maybe it's because it's different numbers again and you're used to doing it a different way. They're worded differently and it makes you think you're doing it wrong.

JB What about when you do a topic, a chapter in your book and then, I don't know how many weeks later you do the next book, and it has a similar topic in it, can you remember back?

mom

L Only parts of it, yeh some of it, like if it's gradient you might think - angle - you know it's some~~thing to~~ do with angle and that's it.

JB Do you think there's a lot to learn in maths?

Both Yes.

JB You do?

model

n
rules

S Yeh all the formulas and rules and that and how things are different.

L There's a lot ~~to learn~~, but .. not a lot that you need to know, ~~I dunno if th~~at makes sense?

S No it doesn't!

el

L Like there's a lot to learn, for the exam, but not a lot that you need to know, out of the exam.

JB Uh huh, you need to learn things for the exam..

rel
model

L But after the exam you don't need ~~to know it, d'you kn~~ow what I mean, it's this big build up for the exam, but after the exam you can just forget it all, you don't need to know it anymore.

JB ~~So~~ what is all of this stuff you ne~~ed to~~ learn?

ules

L Rules, trigonometry, pythagoras' rule.

S ~~When~~ do you use pythagoras rule?

L Well, I don't know about that .

rel

S Same here!

L Stuff like gradient, circumferences, and a lot of algebra, there's a lot of like, if x is 10 what is y, or whatever.

S And whether or not you can let x = 0 to do the rest of it.

JB And you need to learn that stuff?

ar

S Yeh you have to learn it so that you can tell the difference in the question as to which rules you use.

JB Right, OK, a lot of you seem to like English at this school, why do you think that is?

S I think we've got good Eng~~lish teachers~~.

var
gp

L Yeh and in English you can do anything, like read a book, watch a video, you can do debates, talks, write about things, you can go to an English lesson and just pick a subject and just talk about it, there's a lot of discussion which is not like maths, which is just - the textbook.

JB OK, well I'd better let you get back now, thanks very much you've been really good.

dis

S Do we have to go back?

JB Yes, but thanks a lot.

Appendix 3 Student Interview Codes

Year 10 Interview Codes

Category	Code
Pace of work	
Pace	*pace*
Set	*set*
Mathematical Approach	
View of maths	*math*
Amount of maths	*am*
Variety in approach	*var*
Choice of activity	*cho*
Use of activities / invs	*proc*
Use of methods	*meth*
Discussing maths	*disc*
Practical work	*prac*
Thinking	*thin*
Affective	
Understanding	*und*
Anxiety, coping	*cop*
Confidence	*conf*
Motivation	*mot*
Interest, enjoyment	*int*
Knowing why	*why*
Importance	*imp*
Difficulty	*diff*
Transfer	
'Transfer'	*tran*
Recall of work	*recall*
Out of school maths	*out*
Maths in other subjects	*sch*
Making use f maths	*use*
Social setting	*soc*

Teaching Style

Teaching style	*st*
The teacher	*teach*
Discipline	*dis*
Explanations / help	*exp*
Revision	*rev*
Assessment	*ass*

Other

Gender	*gen*
Homework	*home*
Qualifications	*qual*

Year 11 Interview Codes

Category	Code
Mathematics lessons	
Structure	*str*
Group work	*gp*
Teacher directed	*dir*
Discipline	*disc*
Control	*con*
Freedom	*frd*
Choice	*cho*
Help	*help*
Open	*open*
Closed	*closed*
Booklets	*bookl*
Calculators	*cals*
Coverage	*cov*
Examinations	*exam*
Use of mathematics	
Situated	*sit*
Interpreting what to do	*int*
Apply to other situations	*apply*
Use in 'real world'	*rw*
'Transfer'	*trans*
Views about mathematics lessons	
Interesting	*int*
Boring	*bor*
Variety	*var*
Like or dislike	*like*
Links between content areas	*links*
Contrast between diff approaches	*contr*
Responses to lessons	
Thinking	*thin*
Switched off	*off*
Understanding (or lack of)	*und*
Meaning	*mean*

Involved	*inv*
Disaffection	*dis*
Demand / effort	*dem*
Remember	*mem*
Underachievement	*und*
Learning (reports of)	*lng*
Own thing	*own*
Dependency	*dep*
Views about mathematics	
View of maths (in general)	*model*
Rules	*rules*
Useful (or not)	*use*
Relevance	*rel*
Open	*open*
Setting	
Pace	*pace*
Competition	*comp*
Individualised learning	*indv*
Class work	*class*
Affective	
Blame	*blame*
Anxiety	*anx*
Confidence	*conf*
Proud of work	*proud*
Goals	
Goals/ motivations	*mot*
Expectation	*exp*
Cue-based	*cue*
Gender	*gen*

Appendix 4 Year 9 Questionnaire (reduced)

Name .... Maths class ....

Are you a girl or a boy? girl ☐ boy ☐

1. Do you think you are good, OK or bad at the maths you do in school?

good ☐ OK ☐ bad ☐

2. Do you think you are good, OK or bad at the maths you do outside of school?

good ☐ OK ☐ bad ☐

3. Do you enjoy the maths you do in school?

always ☐ most of the time ☐ sometimes ☐ hardly ever ☐ never ☐

4. Do you think maths is a difficult subject?

very difficult ☐ quite difficult ☐ not very difficult ☐ easy ☐

5. Describe one or more situations when you have used maths outside of school:

____

____

____

____

6. What was the most interesting piece of maths you have ever done in a school lesson?

____

____

____

____

Please turn over

7. How could maths be more interesting for you?

8. What do you like about the way that you do maths in school?

9. What do you dislike about the way that you do maths in school?

10. Do you think that the maths you do at school is useful for situations outside of school?

most of the time ☐ sometimes ☐ hardly ever ☐ never ☐

11. What job would you like to do when you leave school?

12. Do you think that the maths that you do at school would be useful for this job?

yes ☐ I don't know ☐ no ☐

13. Look at the areas of maths below and

Put a tick by any that you like doing in the 'like' box.

Put a tick by any that you don't like doing in the 'dislike' box.

Put a tick by any that you find difficult in the 'difficult' box.

Put a tick by any that you think are important for your everyday life in the 'important' box.

	like	dislike	difficult	impor-tant
Doing problems with shapes and angles	☐	☐	☐	☐
Doing number calculations	☐	☐	☐	☐
Doing investigations	☐	☐	☐	☐
Drawing graphs and diagrams	☐	☐	☐	☐
Doing measurement problems	☐	☐	☐	☐
Working out probability and chance	☐	☐	☐	☐
Looking for patterns in numbers	☐	☐	☐	☐
Learning rules and formulas	☐	☐	☐	☐
Estimating	☐	☐	☐	☐
Collecting your own data and putting it into graphs and charts	☐	☐	☐	☐
Doing problems that involve lots of different areas of maths	☐	☐	☐	☐

Thank you for your help

Appendix 5: Year 10 Questionnaire (reduced)

Dear student, please give your honest views about your maths lessons
This information will be kept completely confidential and will not be shown to any teachers.

Name ______________________ Girl ☐ Boy ☐ Year_______ Maths group

1. Do you enjoy maths lessons? always ☐ sometimes ☐ never ☐

2. Are you good, OK or bad at maths? good ☐ OK ☐ bad ☐

3. Put each of these in order of importance in maths lessons.

working at a fast pace | getting a lot of work done | remembering rules and methods | understanding work | knowing how to use a calculator

1. ______________________________ (most important)
2. ______________________________ (next important)
3. ______________________________ (next important)
4. ______________________________ (next important)
5. ______________________________ (least important)

4. Are you worried or confident about your maths GCSE?

worried ☐ OK ☐ confident ☐

5. Do maths lessons have a relaxed atmosphere? often ☐ sometimes ☐ never ☐

6 When you are working is it more important to try and remember similar work you have d ne before or think hard about the work you are doing?

remember ☐ <u>or</u> think ☐

7. Write a sentence which you could use to describe your maths lessons to someone from another school

____

____

____

PTO

8. Which of these words or phrases would you use to describe maths lessons?

(tick any you would use)

difficult	☐	fast	☐	useful	☐
interesting	☐	boring	☐	very similar	☐
easy	☐	relaxed	☐	very varied	☐

9. In maths lessons do you ever feel anxious or worried about work? often ☐ sometimes ☐ never ☐

10. Look at the list below and put a + by anything you would like more of and a − by anything you would like less of:

book work	☐	variety in lessons	☐
activities	☐	choice about what you do	☐
practical work	☐	help from the teacher	☐
computer work	☐		

11. What do you like about maths lessons?

____

____

____

12. What do you dislike about maths lessons?

____

____

____

13 Describe the best maths lesson you have ever had.

____

____

____

Thank you for your help

Appendix 6 Year 11 Questionnaire (reduced)

In this questionnaire you will be asked to answer some general questions about school, some questions about maths lessons and some questions about your home. All of the answers will be kept completely confidential and will not be read by anybody at school.

Name: [ ] female [ ] male [ ] maths group

1. What are your favourite 2 subjects at school?

[ ] [ ]

2. Which 2 school subjects are you best at?

[ ] [ ]

3. Do you ever get into trouble at school because teachers think you are badly behaved? (please tick one box)

all of the time [ ] a lot [ ] not very often [ ] never [ ]

4. When a teacher tells you to do something, do you usually: (please tick one box)

do it because the teacher has told you to [ ] do it if you agree and you think it is fair [ ] not do it at all [ ]

5. Which of the following statements do you agree / disagree with? (please circle one answer for each.)

I'd rather do other subjects than maths	agree	disagree
anyone can be succesful in maths if they work hard enough	agree	disagree
I enjoy working on maths problems	agree	disagree
most of maths is just repeating the same sort of thing over and over again	agree	disagree
you don't need to understand maths, as long as you can follow the rules	agree	disagree
making mistakes helps you to learn	agree	disagree
maths is easy for me	agree	disagree
there are a lot of different things to learn in maths	agree	disagree
maths is one of my favourite five subjects	agree	disagree

6. It is important in maths to ...... please circle one answer for each statement

answer questions the way that the teacher wants you to	agree	disagree
ask for help if you get stuck	agree	disagree
get more things right than other people	agree	disagree
find your own way of solving problems	agree	disagree
use your imagination	agree	disagree
think about different types of maths	agree	disagree
remember lots of rules	agree	disagree

7. Do you prefer maths when: (please tick one box)

you know exactly what to do and you can follow a clear step-by-step order OR ☐

you can try different things out for yourself ☐

8. Say whether you agree or disagree with each of the following (circle one answer for each):

I feel pleased in maths when I finish before my friends	strongly agree	agree	disagree	strongly disagree	never happens
I feel pleased in maths when I find work interesting	strongly agree	agree	disagree	strongly disagree	never happens
I feel pleased in maths when I get everything right	strongly agree	agree	disagree	strongly disagree	never happens
I feel pleased in maths when the teacher tells me exactly what to do	strongly agree	agree	disagree	strongly disagree	never happens
I feel pleased in maths when I find work easy	strongly agree	agree	disagree	strongly disagree	never happens
I feel pleased in maths when I am the only one who can answer a question	strongly agree	agree	disagree	strongly disagree	never happens
I feel pleased in maths when I solve a problem by working really hard	strongly agree	agree	disagree	strongly disagree	never happens

9. Do you think you are well behaved in maths lessons? (please tick one box)

always ☐ most of the time ☐ hardly ever ☐ never ☐

10. When you cannot work something out do you usually: (please tick one box)

give up ☐ ask for help ☐ try harder ☐

11. Do you ever feel scared of your maths teacher? (please tick one box)

always ☐ often ☐ sometimes ☐ never ☐

12. When did you enjoy your maths the most? (please tick one box)

primary school ☐ years 7 and 8 ☐ year 9 and above ☐

13. Please list the jobs of the adults you live with and say what the person is to you eg mother, father, guardian. Please also describe the sort of work the job involves.

If they are unemployed at the moment, put what job they would normally do.
If they spend their time raising children or doing housework, write housework.

adult	job title	work involves

Appendix 7 Year 9 Questionnaire Results

The results for the year 9 questionnaire are presented as follows.

Pages 303 to 305 show the quantitative results for the students at the two schools (n and %).

Pages 306 to 311 show the quantitative results for the girls and boys separately at the two schools.

Pages 312 to 317 show the qualitative results for the students at the two schools on a number of different systemic network diagrams (Bliss, Monk & Ogborn, 1983).

The first network diagram shows the responses to the question 'What do you like about the way you do maths at school?'

The second diagram is presented in two sections. It shows the students' responses to the question 'What do you dislike about the way you do maths at school?'. The first part is a combined network, the second part separates out all of the responses which related to the chosen approach at each school and these are given for each school separately.

The third diagram shows the responses to the question 'What was the most interesting piece of maths you have ever done in a lesson?'

The fourth diagram shows the responses to the question 'How could maths be more interesting for you?'

The final diagram shows the responses to the question 'Describe one of more situations when you have used maths outside of school.'

Year 9 Questionnaire Quantitative Results n and (%)

Are you a girl or a boy?	girl	boy
AH	83 (52)	77 (48)
PP	43 (42)	60 (58)

Are you good, OK or bad at the maths you do at school?	good	OK	bad
AH	30 (19)	117 (73)	12 (8)
PP	23 (22)	70 (68)	10 (10)

$\chi^2 = 1.00$, $p < 0.71$, d.f. = 2

Are you good, OK or bad at the maths you do outside of school?	good	OK	bad
AH	30 (19)	119 (74)	9 (6)
PP	14 (14)	73 (71)	15 (15)

$\chi^2 = 6.58$, $p < 0.05$, d.f. = 2

Do you enjoy the maths you do at school?	always	most of the time	sometimes	hardly ever	never
AH	10 (6)	59 (37)	77 (48)	12 (8)	1 (1)
PP	4 (4)	50 (49)	31 (30)	13 (13)	5 (5)

$\chi^2 = 10.75$, $p < 0.01$, performed on collapsed table, combining always & most of the time, hardly ever & never, d.f. = 2

Do you think maths is a difficult subject?	very difficult	quite difficult	not very difficult	easy
AH	3 (2)	102 (64)	46 (29)	9 (6)
PP	5 (5)	59 (57)	36 (35)	3 (3)

$\chi^2 = 0.33$, $p < 0.70$, performed on collapsed table, combining very & quite difficult, not very difficult & easy, d.f. = 1

Do you think that the maths you do at school is useful for situations outside of school?	most of the time	sometimes	hardly ever	never
AH	66 (41)	79 (49)	13 (8)	2 (1)
PP	22 (21)	54 (52)	20 (19)	7 (7)

$\chi^2 = 18\ 65$, $p < 0\ 001$, performed on collapsed table, combining hardly ever & never, d.f. = 3

Do you think that the maths you do at school will be useful for the job you intend to do?	yes	not sure	no
AH	83 (52)	66 (41)	6 (4)
PP	34 (33)	48 (47)	18 (17)

$\chi^2 = 18.35, p < 0.001$, d.f. = 2

In the following question students were asked to tick the boxes of any areas they found particularly difficult, important or that they liked or disliked:

	like	dislike	difficult	important
Doing problems with shapes and angles: AH	75 (47)	62 (39)	30 (19)	23 (14)
PP	61 (59)	37 (36)	7 (7)	8 (8)
$\chi^2 = 10.41, p < 0.02$, d.f. = 3				
Doing number calculations AH	102 (64)	29 (18)	9 (6)	80 (50)
PP	55 (53)	33 (32)	12 (12)	35 (34)
$\chi^2 = 12.74, p < 0.01$, d.f. = 3				
Doing investigations AH	64 (40)	60 (38)	41 (26)	38 (24)
PP	59 (57)	32 (31)	16 (16)	12 (12)
$\chi^2 = 12.12, p < 0.01$, d.f. = 3				
Drawing graphs and diagrams AH	112 (70)	29 (18)	11 (7)	50 (31)
PP	64 (62)	33 (32)	6 (7)	24 (23)
$\chi^2 = 7.23, p < 0.1$, d.f. = 3				
Doing measurement problems AH	54 (34)	71 (44)	32 (30)	57 (36)
PP	22 (21)	65 (63)	8 (8)	28 (27)
$\chi^2 = 14.52, p < 0.01$, d.f. = 3				
Working out probability and chance AH	41 (26)	71 (44)	46 (29)	47 (29)
PP	38 (37)	48 (47)	22 (21)	14 (14)
$\chi^2 = 10.49, p < 0.02$, d.f. = 3				

Looking for patterns in numbers AH	84 (53)	50 (31)	34 (21)	33 (21)
PP	46 (45)	39 (38)	18 (17)	11 (11)
$\chi^2 = 4.72, p < 0.20$, d.f. = 3				
Learning rules and formulas AH	44 (28)	64 (40)	53 (33)	61 (38)
PP	30 (29)	49 (48)	22 (21)	24 (23)
$\chi^2 = 7.00, p < 0.10$, d.f. = 3				
Estimating AH	78 (49)	46 (29)	21 (13)	57 (36)
PP	36 (35)	48 (47)	13 (13)	32 (31)
$\chi^2 = 8.75, p < 0.05$, d.f. = 3				
Collecting data & graphs & charts AH	95 (59)	37 (23)	28 (18)	50 (31)
PP	54 (52)	29 (28)	12 (12)	22 (21)
$\chi^2 = 3.36, p < 0.50$, d.f. = 3				
Problems involving different areas of maths AH	53 (33)	54 (34)	51 (32)	75 (47)
	43 (42)	35 (34)	20 (19)	27 (26)
$\chi^2 = 9.51, p < 0.05$, d.f. = 3				
	like	dislike	difficult	import
Average AH	53 (33)	54 (34)	51 (32)	75 (47)
PP	43 (42)	35 (34)	20 (19)	27 (26)
$\chi^2 = 9.51, p < 0.05$, d.f. = 3				

Year 9 Questionnaire Quantitative Results
Amber Hill Gender Results (n)

Are you a girl or a boy?

girl	83
boy	77

Are you good, OK or bad at the maths you do at school?	good	OK	bad
girl	5	66	11
boy	25	51	1

Are you good, OK or bad at the maths you do outside of school?	good	OK	bad
girl	7	68	7
boy	23	51	2

Do you enjoy the maths you do at school?	always	most of the time	sometimes	hardly ever	never
girl	6	24	43	8	1
boy	4	35	34	4	0

Do you think maths is a difficult subject?	very difficult	quite difficult	not very difficult	easy
girl	3	54	24	2
boy	0	48	22	7

Do you think that the maths you do at school is useful for situations outside of school?	most of the time	sometimes	hardly ever	never
girl	33	37	11	2
boy	33	42	2	0

Do you think that the maths you do at school will be useful for the job you intend to do?	yes	not sure	no
AH	36	41	3
PP	47	25	3

In the following question students were asked to tick the boxes of any areas they found particularly difficult, important or that they liked or disliked:

	like	dislike	difficult	important
Doing problems with shapes and angles: g	34	34	17	8
b	41	28	13	15
Doing number calculations g	54	16	4	37
b	48	13	5	43
Doing investigations g	34	32	30	15
b	30	28	21	23
Drawing graphs and diagrams g	59	17	5	14
b	53	12	6	36
Doing measurement problems g	24	47	13	20
b	30	24	19	37
Working out probability and chance g	19	37	26	19
b	22	34	20	28
Looking for patterns in numbers g	42	26	18	9
b	42	24	16	24
Learning rules and formulas g	18	39	29	23
b	26	25	24	38
Estimating g	36	27	13	26
b	42	19	8	31

Collecting data / graphs & charts g	51	13	18	19
b	44	24	10	31

Problems involving different areas of maths g	24	26	31	35
b	29	28	20	40

	like	dislike	difficult	import
Average g	35.9	28.5	17.6	20.5
b	37	23.5	14.7	31.5

$\chi^2 = 3.00, p < 0.50, d.f. = 3$

Year 9 Questionnaire Quantitative Results
Phoenix Park Gender Results (n)

Are you a girl or a boy?

girl	43
boy	60

Are you good, OK or bad at the maths you do at school?	good	OK	bad
girl	10	31	2
boy	13	39	8

Are you good, OK or bad at the maths you do outside of school?	good	OK	bad
girl	7	33	3
boy	7	40	12

Do you enjoy the maths you do at school?	always	most of the time	sometimes	hardly ever	never
girl	3	24	10	5	1
boy	1	26	21	8	4

Do you think maths is a difficult subject?	very difficult	quite difficult	not very difficult	easy
girl	1	21	20	1
boy	4	38	16	2

Do you think that the maths you do at school is useful for situations outside of school?	most of the time	sometimes	hardly ever	never
girl	12	22	7	2
boy	10	32	13	5

Do you think that the maths you do at school will be useful for the job you intend to do?

	yes	not sure	no
AH	11	23	7
PP	23	25	11

In the following question students were asked to tick the boxes of any areas they found particularly difficult, important or that they liked or disliked:

	like	dislike	difficult	important
Doing problems with shapes and angles: g	26	16	0	2
b	35	21	7	6
Doing number calculations g	25	14	4	14
b	30	18	8	21
Doing investigations g	26	13	7	5
b	33	19	9	7
Drawing graphs and diagrams g	29	15	3	8
b	35	18	3	16
Doing measurement problems g	11	28	2	14
b	11	37	6	14
Working out probability and chance g	20	15	10	6
b	18	33	12	8
Looking for patterns in numbers g	22	14	9	3
b	24	25	9	8
Learning ru and formulas g	12	18	9	14
b	18	31	13	10
Estimating g	16	18	7	13
b	20	30	6	19

Collecting data / graphs & charts g	21	12	4	10
b	33	17	8	12

Problems involving different areas of maths g	20	11	10	12
b	23	24	10	15

	like	dislike	difficult	import
Average g	20.7	15.8	5.9	9.2
b	25.5	24.9	8.3	12.4

$\chi^2 = 0.32, p < 0.98$, d.f. = 3

What do you like about the way you do maths at school?

- approach 27 29
  - open ended work
    - project work
      - is interesting 0 11
      - working on projects 7 4
    - solving problems 0 4
    - investigating 2 5
    - extending work 0 5
    - 0 — 134 74
    - 1 — 27 29
  - text book work
    - general
      - using textbooks 7 0
      - doing reviews 2 0
      - you are told what to do 1 0
    - variety
      - one book with everything in 3 0
      - each chapter is different 5 0
  - variety of work 1 4
- understanding 26 7
  - diff culty
    - I can understand the problems 1 5
    - I like questions I can do 4 0
    - when I know what to do 8 0
    - it is easy 2 0
    - it is hard 1 0
    - it is challenging 0 2
  - 0 — 135 96
  - 1 — 26 7
  - exp anations
    - when teacher helps 6 0
    - when work is explained 4 0
- group work 31 9
  - working alone 12 0
  - working with others 19 7
  - work ng in large group 0 2
  - 0 — 130 94
  - 1 — 31 9
- pace 9 7
  - time
    - no pressure to keep up 0 3
    - working at own speed 0 2
    - when I have enough time 3 0
  - depth — spending time on things you are interested in 0 2
  - 0 — 152 96
  - 1 — 9 7
  - streaming
    - being in class of same ability 2 0
    - everyone working at same pace 3 0
    - competition 1 0
- content 17 4
  - technology
    - computers 6 0
    - calculators 4 0
  - puzzles / games — 1 1
  - content
    - graphs 2 1
    - mental arithmetic 0 1
    - number work 3 0
  - 0 — 144 100
  - 1 — 17 2
  - 2 — 0 1
  - general
    - writing 0 1
    - different areas of maths 1 0
- teacher 7 0
  - the teacher 3 0
  - tells jokes 4 0
  - 0 — 154 103
  - 1 — 7 0
- general 61 45
  - everything 6 15
  - nothing 7 12
  - don't know 6 0
  - it is different 0 2
  - it is boring 13 0
  - too much homework 4 0
  - can't use in real life 2 0
  - no answer 23 16
  - 0 — 100 58
  - 1 — 61 45

Amber Hill Phoenix Park

What do you dislike about the way you do maths at school?

Category	Subcategory	Response	Amber Hill	Phoenix ark
understanding (28 10)	difficulty	work is too difficult	5	3
		work is too easy	0	2
	understanding	can t understand the work	8	0
		when I don t understand	0	2
		work isn't explained properly	5	0
		you can never catch up	2	0
	help	when teacher doesn't help	0	3
		can t ask for help	2	0
		teacher shouts if don t understand	4	0

0	133	93
1	28	10

Category	Subcategory	Response	Amber Hill	Phoenix ark
content (9 4)	number	percentages	1	0
		too many sums	2	1
		simp e basic maths	1	0
	algebra		1	0
	graphs		2	1
	measuring		0	1
	everything becomes a table		0	1
	remembering ru es		1	0
	not enough computer work		1	0

0	153	99
1	7	2
2	1	1

Category	Response		Amber Hill	Phoenix ark
teacher (11 10)	the teacher		0	6
	can't understand		6	2
	talks too much		3	2
	keeps interrupting work		2	0

0	150	93
1	11	10

Category	Response		Amber Hill	Phoenix ark
general (37 63)	everything		8	6
	nothing		6	6
	don t know		0	6
	it's boring		10	13
	too much work	class	0	2
		home	0	4
	no help in 'real life'		1	2
	work is outdated		2	0
	people who cheat		0	1
	no answer		10	23

0	126	40
1	33	63
2	2	0

Amber Hill Phoenix ark

What do you dislike about the way you do maths at school? - Amber Hill

- approach 49
  - textbook 45
    - using 27
      - using textbooks 4
      - using books all the time 10
      - books go on too long 7
      - teachers skip chapters 3
      - preferred booklets 3
    - content 18
      - too hard 3
      - boring 5
      - qu s too long 1
      - qu s repetitive 2
      - reviews
        - doing reviews 4
        - too long 1
        - boring 1
        - doing exams 1
  - choice 4
    - can t choose order 2
    - can t choose topics 2

- 0 — 113
- 1 — 47
- 2 — 1

- pace 25
  - time 14
    - always rushing work 9
    - move on before understand 3
    - too much to do in 1 hour 2
  - freedom 11
    - can t work at own pace 5
    - can t work at own level 6

- 0 — 136
- 1 — 25

- group work 4
  - never do class activities 1
  - can t work with others 2
  - all do same book 1

- 0 — 157
- 1 — 4

What do you dislike about the way you do maths at school? - Phoenix Park

- approach 15
  - projects
    - too much problem solving 2
    - project too long 8
    - too much writing 2
  - change
    - change subjects too often 1
    - some project too similar 2

- 0 — 94
- 1 — 15

What was the most interesting piece of maths you have ever done in a lesson?

Category	Subcategory	Item	Amber Hill	Phoenix Park
content area 45 3	number	rules and formulae	3	0
		negative numbers	1	0
		decimal numbers	3	0
		adding numbers	1	1
		percentages	2	0
		3 rules of number	1	0
		fraction work	0	1
	algebra	algebra	14	0
		balancing	2	0
		equations and graphs	0	1
	shape space	area / perimeter	3	0
		loci	2	0
		circle work	1	0
		impossible objects	4	0
		shape	2	0
		reflection	2	0
	data handling	graph work	4	0
general 21 20	practical	practical work	1	1
		weighing things	2	0
		working outside	1	0
		doing investigations	2	0
		calculator	1	0
		old book ets	4	0
		SMILE	1	0
		everything	0	8
		nothing	1	0
		don t know	4	0
		no answer	8	12

	Amber Hill	Phoenix Park
0	8	12
1	152	91

Category	Item	Amber Hill	Phoenix Park
projects 90 79	logo	78	11
	frogs	0	10
	probability project	0	9
	maths day	0	8
	limping seagulls	0	6
	cube project	7	0
	car survey	4	0
	cheese investigations	0	2
	cargo	1	0
	designing a garden	0	1
	making a box	0	1
	corridor length	0	1
	time table	0	1
	charts on the board	0	1
	arrangements	0	4
	squares	0	2
	statistics	0	3
	bouncing ball	0	1
	ruler and boxfile	0	2
	boxes / cubes	0	3
	outing work	0	1
	doing posters	0	1
	timetables	0	1
	calendar calculations	0	1
	chessboard	0	1
	sequences	0	4
	measuring the tennis courts	0	1
	behaviour surveys	0	1
	the water tank	0	3

Amber Hill Phoenix Park

How could maths be more interesting for you?

Category	Subcategory	Response	Amber Hill	Phoenix Park
approach 84 66	open ended work	more problem solving	0	4
		more practical work	21	15
		more games	15	19
		more project work	7	0
		more investigations	2	0
	textbook work	less textbook work	6	0
		more book work	0	2
		less of the same questions	3	0
		shorter chapters and reviews	2	0
		go back to booklets	1	0
	variety	do different types of maths	6	0
		do different things	0	3
		make own choices	4	0
	interest	more interesting work	10	5
		more fun	0	6
		more outside work	2	10
		more maths days	0	2
		less board work	5	0
understanding 32 4	difficulty	less difficult work	10	1
		more difficult work	3	2
		if I could understand	6	0
	explanations	if work was explained more	7	1
		if work was explained better	3	0
		more diagrams/stories to explain work	2	0
		work in groups so you can understand	1	0
group work 17 1		more group work	10	1
		more pair work	2	0
		more whole class activities	5	0
pace 2 0		need more time	1	0
		work at own pace	1	0
content 48 16	technology	more calculator work	2	0
		more computer work	34	9
		more logo	2	0
	content	more data handling – more surveys	3	2
		more data handling – more tables	1	0
		more data handling – more graphs	3	2
		more algebra	1	0
		more loci	1	0
		more drawing work	1	1
		more arranging problems	0	1
		more sports questions	0	1
general 11 33		it can't	4	7
		don't know	5	12
		being in a higher set	2	0
		having a better teacher	0	4
		having more lessons	0	2
		no answer	0	8

Approach:

	Amber Hill	Phoenix Park
0	85	45
1	68	50
2	8	8

Understanding:

	Amber Hill	Phoenix Park
0	130	99
1	30	4
2	1	0

Group work:

	Amber Hill	Phoenix Park
0	144	102
1	17	1

Pace:

	Amber Hill	Phoenix Park
0	159	103
1	2	0

Content:

	Amber Hill	Phoenix Park
0	118	88
1	39	14
2	3	1
3	1	0

General:

	Amber Hill	Phoenix Park
0	151	70
1	9	33
2	1	0

Amber Hill Phoenix Park

Describe one or more situations when you have used maths outside of school

Category	Amber Hill	Phoenix Park	Sub-category	Item	Amber Hill	Phoenix Park
shopping / money	123	52				
at home	24	11		with maths tut r	2	0
				h e v k	22	11
games	14	23	games	games	5	12
				darts	3	5
				snooker	0	3
				computer	5	1
				TV programme	0	1
				sports	1	1
time	5	0		waiting for bus	1	0
				looking at time	3	0
				bus timetable	1	0
data handling	0	9		sorting out magazine collection	0	1
				organising bank account	0	1
				choosing options at the centre	0	1
				organising the colour of cars	0	3
				organising paper round	0	3

	Amber Hill	Phoenix Park
0	3	7
1	130	89
2	24	2
3	0	1

Category	Amber Hill	Phoenix Park	Item	Amber Hill	Phoenix Park
measurement	12	1	measuring	5	0
			measuring room	3	0
			cooking	4	0
			weighing things	0	1
shape / space	0	5	carpentry	0	2
			laying slabs	0	1
			map reading	0	1
			redecorating	0	1
counting	3	0	stickers	1	0
			dog years	1	0
			bus wheels	1	0
general	6	10	at guides	1	0
			in sport	1	0
			continental shoe sizes	1	0
			football pools	0	1
			working at club	0	1
			playing 'kerby'	0	1
			no answer	3	7

Amber Hill Phoenix Park

Appendix 8 Year 10 Questionnaire Results

The 'year 10' questionnaire was taken by the case study year group when they were in year 10 as well as the year group above and below them. It combined quantitative and qualitative sections. Pages 319 to 334 show the year 10 results, pages 332 to 344 show all of the results for years 9, 10 and 11 combined. Pages 345 to 354 show the year 9 results and pages 355 to 358 the year 11 results.

Quantitative and qualitative results are given for each of the individual year groups. The year 10 quantitative results and the quantitative results for all three year groups combined are analysed for gender differences.

Year 10 Questionnaire Quantitative Results
Amber Hill and Phoenix Park n and (%)

Amber Hill n = 163
Phoenix Park n = 75

Are you a girl or a boy?	girl	boy
AH	74 (45)	89 (55)
PP	32 (43)	43 (57)

Do you enjoy maths lessons?	always	sometimes	never
AH	14 (9)	127 (78)	22 (14)
PP	6 (8)	66 (88)	3 (4)

Are you good, OK or bad at maths?	good	OK	bad
AH	26 (16)	128 (79)	9 (6)
PP	10 (13)	55 (73)	9 (12)

$\chi^2 = 3.3$, $p < 0.20$, d.f. = 2

Priority of: working fast	1	2	3	4	5
AH	2 (1)	5 (3)	12 (7)	41 (25)	103 (65)
PP	1 (1)	7 (9)	12 (16)	25 (33)	30(40)

$\chi^2 = 13.29$, $p < 0.01$, performed on collapsed table with 1 & 2 combined, d.f. = 3

Priority of: getting lots done	1	2	3	4	5
AH	9 (6)	12 (7)	46 (28)	76 (47)	20 (12)
PP	10 (13)	15 (20)	25 (33)	22 (29)	3 (4)

$\chi^2 = 18.21$, $p < 0.001$, performed on collapsed table with 4 & 5 combined, d.f. = 3

Priority of: remembering rules	1	2	3	4	5
AH	24 (15)	104 (64)	23 (14)	8 (5)	4 (3)
PP	6 (8)	40 (53)	18 (24)	7 (9)	4 (5)

$\chi^2 = 8.53$, $p < 0.001$, performed on collapsed table with 4 & 5 combined, d.f. = 3

Priority of: understanding	1	2	3	4	5
AH	125 (77)	26 (16)	8 (5)	4 (3)	0 (0)
PP	57 (76)	11 (15)	1 (1)	4 (5)	2 (3)

Priority of: using a calculator	1	2	3	4	5
AH	3 (2)	17 (10)	73 (45)	34 (21)	36 (22)
PP	1 (1)	2 (3)	19 (25)	17 (23)	36 (48)

Are you worried or confident about maths GCSE?	worried	OK	confident
AH	64 (39)	87 (53)	11 (7)
PP	26 (35)	45 (60)	3 (4)

Do maths lessons have a relaxed atmosphere?	often	sometimes	never
AH	39 (24)	97 (60)	19 (12)
PP	28 (37)	42 (56)	4 (5)

Do you ever feel worried or anxious about work?	often	sometimes	never
AH	21 (13)	104 (60)	32 (21)
PP	10 (13)	45 (64)	16 (20)

$\chi^2 = 0.19, p < 0.95$, d.f. = 2

Chosen words to describe maths lessons	difficult	interesting	easy
AH	69 (43)	82 (50)	18 (11)
PP	32 (42)	28 (37)	6 (8)
$\chi^2 =$	0.0 $p < 1.0$	3.5 $p < 0.10$	0.5 $p < 0.50$

Chosen words to describe maths lessons	fast	boring	relaxed
AH	36 (22)	75 (46)	56 (34)
PP	11 (15)	38 (51)	27 (36)
$\chi^2 =$	1.8 $p < 0.20$	0.5 $p < 0.50$	0.1 $p < 0.80$

Chosen words to describe maths lessons	useful	similar	varied
AH	98 (60)	42 (26)	44 (27)
PP	39 (52)	15 (20)	24 (32)
$\chi^2 =$	1.4 $p < 0.30$	0.9 $p < 0.50$	0.6 $p < 0.50$

Aspects students would like more of	bookwork	activities	practical	computer
AH	28 (17)	131 (80)	124 (76)	156 (96)
PP	23 (31)	44 (59)	45 (60)	67 (89)
$\chi^2 =$	5.6 $p < 0.02$	12.4 $p < 0.001$	6.5 $p < 0.02$	3.5 $p < 0.10$

Aspects students would like more of	variety	choice	teacher help
AH	121 (74)	141 (87)	116 (71)
PP	46 (61)	58 (77)	44 (59)
$\chi^2 =$	4.1 $p < 0.05$	3.2 $p < 0.10$	3.6 $p < 0.10$

Aspects students would like less of	bookwork	activities	practical	computer
AH	113 (69)	16 (10)	21 (13)	6 (4)
PP	36 (48)	16 (21)	13 (17)	11 (15)
$\chi^2 =$	10.0 $p < 0.01$	5.9 $p < 0.02$	0.83 $p < 0.50$	9.4 $p < 0.01$

Aspects students would like less of	variety	choice	teacher help
AH	19 (12)	8 (5)	14 (9)
PP	13 (17)	7 (9)	13 (17)
$\chi^2 =$	1.4 $p < 0.30$	1.7 $p < 0.20$	3.9 $p < 0.05$

Is it more important to remember similar work or think hard?	remember	think
AH	104 (64)	59 (36)
PP	26 (35)	49 (65)

$\chi^2 = 17.6$, $p < 0.001$, d.f. = 1

Year 10 Questionnaire Qualitative Results
Amber Hill and Phoenix Park n and (%)

1. Write a sentence which you could use to describe your maths lesson to someone fro another school

AH: 154 sentences from 163 students
PP: 68 sentences from 75 students

	AH (n)	PP (n)	AH (%)	PP (%)
very positive	0	2	0	3
positive	36	26	22	35
neutral	58	20	36	27
negative	51	19	31	25
very negative	9	0	6	0
no answer	9	8	6	11

$\chi^2 = 7.74$, d.f. = 2, $p < 0.05$, perfomed on collapsed table with very positive & positive, negative v negative combined

Sentences referred to:

	AN n	PP n	AH (%)	PP (%)
difficulty	40	3	25	4
teacher	36	5	22	7
boring	28	6	17	8
structure	18	0	11	0
bookwork	17	2	10	3
speed / pace	16	2	10	3
mixed boring & int	13	9	8	12
pressure / anxiety	9	1	6	1
noisy	7	17	4	23
interesting	6	11	4	15
rules / equations	5	0	3	0
other students	4	0	2	0
activities	0	5	0	7
independence		8	0	11

2. What do you like about maths lessons?

AH: 128 sentences from 163 students
PP: 68 sentences from 75 students

	AH (n)	PP (n)	AH (%)	PP (°)
very positive	2	5	1	7
positive	63	46	39	61
neutral	61	7	37	9
negative	22	10	14	13
very negative	4	0	2	0
no answer	11	7	7	9

$\chi^2 = 22.96$, d.f. = 2, $p < 0.001$, performed on collapsed table with very positive and positive, negative and very negative combined

	AN n	PP n	AH (%)	PP (%)
when we do activities	50	0	31	0
the teacher	31	6	19	8
computer work	23	1	14	1
when I understand	15	0	9	0
learning things	10	4	6	5
enjoy the maths	4	13	3	17
relaxed atmosphere	9	17	6	23
working at own pace	10	2	6	3
lessons are fun	8	3	5	4
(some) work is interesting	7	5	4	7
group work	7	2	4	3
useful	3	6	2	8
because I understand	3	0	2	0
something other than maths	14	3	9	4
variety	6	1	4	1
geting a good mark	6	0	4	0
independence	0	4	0	5
starting a new subject	0	2	0	3
having to think	0	6	0	8
rules / formulae	1	1	0	1
content area	0	2	0	3
nothing	11	10	7	13
no answer	11	7	7	9

3. What do you dislike about maths lessons?

AH: 152 sentences from 163 students
PP: 67 sentences from 75 students

	AH (n)	PP (n)	AH (%)	PP (%)
very positive	0	0	0	0
positive	5	7	3	9
neutral	17	5	10	7
negative	116	54	71	72
very negative	14	1	9	1
no answer	11	8	7	11

	ANn	PPn	AH (%)	PP (%)
the bookwork (AH) the activities (PP)	35	3	22	4
too fast	17	2	10	3
pressure / anxiety	5	0	3	0
work is boring	27	12	17	16
work is all the same	31	1	19	1
not understanding	32	7	20	9
all of the work	11	4	7	5
the teacher	18	9	11	12
content	6	2	4	3
blackboard work	8	1	5	1
never learn anything	8	0	5	0
not enough activities	9	0	6	0
not enough computer wk	3	1	2	1
tests	10	0	6	0
homework	4	0	2	0
something other than maths	8	0	5	0
too noisy	1	11	1	15
activities are too long	0	2	0	3
time limits	8	5	5	7
not enough help	3	6	2	8
nothing	5	7	3	9
no answer	11	8	7	11

4. Describe the best maths lesson you have ever had

AH: 153 sentences from 163 students
PP: 59 sentences from 75 students

	ANn	PPn	AH (%)	PP (%)
coursework project (AH) a named activity (PP)	102	31	63	41
computer work	14	0	9	0
practical work	7	2	4	3
content	5	1	3	1
teacher was away	4	4	3	5
didn't do any maths	10	1	6	1
haven't had one	15	10	9	13
nice atmosphere	1	3	1	4
when I could understand	5	0	3	0
group work	3	1	2	1
got a good mark in test	2	0	1	0
when teacher nice / good	4	0	3	0
when not doing bookwork	2	0	1	0
exam work	1	0	1	0
when good pace	1	0	1	0
don't know	0	5	0	7
no answer	10	16	6	21

Year 10 Questionnaire Quantitative Results
Amber Hill gender results (n)

Amber Hill n = 163

Are you a girl or a boy? n and (%)

G	74 (45))
B	89 (55)

Do you enjoy maths lessons?	always	sometimes	never
G	5	58	11
B	9	69	11

Are you good, OK or bad at maths?	good	OK	bad
G	6	63	5
B	20	65	4

Priority of: working fast	1	2	3	4	5
G	1	2	2	23	46
B	1	3	10	18	57

Priority of: getting lots done	1	2	3	4	5
G	1	3	29	33	8
B	8	9	17	43	12

Priority of: remembering rules	1	2	3	4	5
G	3	56	9	5	1
B	21	48	14	3	3

Priority of: understanding	1	2	3	4	5
G	67	7	0	0	0
B	58	19	8	4	0

Priority of: using a calculator	1	2	3	4	5
G	2	7	33	13	9
B	1	10	41	21	17

Are you worried or confident about maths GCSE?	worried	OK	confident
G	44	26	4
B	20	61	7

Do maths lessons have a relaxed atmosphere?	often	sometimes	never
G	17	47	3
B	22	50	16

Do you ever feel worried or anxious about work?	often	sometimes	never
G	13	52	8
B	8	52	24

$\chi^2 = 8.5$, $p < 0.01$, d.f. = 2

Chosen words to describe maths lessons	difficult	interesting	easy
G	40	32	6
B	29	50	12
$\chi^2 =$	7.6 $p < 0.001$	2.7 $p < 1.0$	1.2 $p < 0.3$

Chosen words to describe maths lessons	fast	boring	relaxed
G	23	35	19
B	13	40	37
$\chi^2 =$	6 4 $p < 0.02$	0.1 $p < 0.80$	4.5 $p < 0.05$

Chosen words to describe maths lessons	useful	similar	varied
G	23	35	19
B	13	40	37
$\chi^2 =$	0 6 $p < 0 50$	3 1 $p < 1$	0.5 $p < 0 50$

Aspects students would like more of	bookwork	activities	practical	computer
G	15	60	56	70
B	13	71	68	86
$\chi^2 =$	0.9 $p < 0.50$	0.0 $p < 1.0$	0.0 $p < 1.0$	0.4 $p < 0.70$

Aspects students would like more of	variety	choice	teacher help
G	61	64	59
B	60	77	57
$\chi^2 =$	4.8 $p < 0.05$	0.0 $p < 1.0$	4.8 $p < 0.05$

Aspects students would like less of	bookwork	activities	practical	computer
G	52	10	13	3
B	61	6	8	3
$\chi^2 =$	0.1 $p < 0.80$	2.1 $p < 0.20$	2.7 $p < 0.20$	

Aspects students would like less of	variety	choice	teacher help
G	8	5	1
B	11	3	13
$\chi^2 =$	0.1 $p < 0.50$		

Is it more important to remember similar work or think hard?	remember	think
G	41	33
B	33	34

$\chi^2 = 0.6$, $p < 0.50$, d.f. = 1

Year 10 Questionnaire Quantitative Results
Phoenix Park gender results (n)

Phoenix Park n = 75

Are you a girl or a boy? n and (%)

G	32 (43)
B	43(57)

Do you enjoy maths lessons?	always	sometimes	never
G	3	28	1
B	3	38	2

Are you good, OK or bad at maths?	good	OK	bad
G	2	29	1
B	8	26	8

Priority of: working fast	1	2	3	4	5
G	0	2	5	12	13
B	1	5	7	13	17

Priority of: getting lots done	1	2	3	4	5
G	2	6	11	11	2
B	8	9	14	11	1

Priority of: remembering rules	1	2	3	4	5
G	2	21	7	2	0
B	4	19	11	5	4

Priority of: understanding	1	2	3	4	5
G	28	3	0	1	0
B	29	8	1	3	2

Priority of: using a calculator	1	2	3	4	5
G	0	0	9	6	17
B	1	2	10	11	19

Are you worried or confident about maths GCSE?	worried	OK	confident
G	12	20	0
B	14	25	3

Do maths lessons have a relaxed atmosphere?	often	sometimes	never
G	8	21	3
B	20	21	1

Do you ever feel worried or anxious about work?	often	sometimes	never
G	8	19	3
B	2	26	13

Chosen words to describe maths lessons	d fficult	interestng	easy
G	19	12	2
B	13	16	4
$\chi^2 =$	6.4 p < 0 02	0.0 p <1.0	

Chosen words to describe maths lessons	fast	boring	relaxed
G	6	19	20
B	5	19	7
$\chi^2 =$		1.7 p <0.20	

Chosen words to describe maths lessons	useful	similar	varied
G	15	5	14
B	24	10	10
$\chi^2 =$	0.6 p < .50		3.5 p < 0.10

Aspects students would like more of	bookwork	activities	practical	computer
G	15	22	22	30
B	8	22	23	37
$\chi^2 =$	6.9 $p < 0.01$	2.3 $p < 0.20$	1.8 $p < 0.2$	1.1 $p < 0.30$

Aspects students would like more of	variety	choice	teacher help
G	24	27	16
B	22	31	27
$\chi^2 =$	4.4 $p < 0.05$	1.6 $p < 0.3$	1.2 $p < 0.30$

Aspects students would like less of	bookwork	activities	practical	computer
G	13	5	5	4
B	23	11	8	7
$\chi^2 =$	1.2 $p < 0.30$			

Aspects students would like less of	variety	choice	teacher help
G	3	2	8
B	10	5	5

Is it more important to remember similar work or think hard?	remember	think
G	13	19
B	13	29

$\chi^2 = 0.7$, $p < 0.50$, d.f. = 1

Years 9, 10 and 11 Questionnaire Quantitative Results
Amber Hill and Phoenix Park n and (%)

Amber Hill n = 420
Phoenix Park n = 233

Are you a girl or a boy?	girl	boy
AH	183 (44)	237 (56)
PP	114 (49)	119 (51)

Do you enjoy maths lessons?	always	sometimes	never
AH	52 (12)	325 (77)	43 (10)
PP	13 (6)	189 (81)	31 (13)

$\chi^2 = 8.5$, $p < 0.02$, d.f. = 2

Are you good, OK or bad at maths?	good	OK	bad
AH	84 (20)	310 (74)	26 (6)
PP	31 (13)	174 (75)	27 (12)

$\chi^2 = 9.2$, $p < 0.02$, d.f. = 2

Priority of: working fast	1	2	3	4	5
AH	5 (1)	14 (3)	38 (9)	81 (19)	282 (67)
PP	5 (2)	14 (6)	27 (12)	78 (34)	106 (46)

$\chi^2 = 28.66$, $p < 0.001$, performed on collapsed table with 1 & 2 combined, d.f. = 3

Priority of: getting lots done	1	2	3	4	5
AH	20 (5)	28 (7)	110 (26)	119 (28)	31 (7)
PP	22 (9)	41 (18)	95 (41)	59 (25)	11 (5)

$\chi^2 = 21.9$, $p < 0.01$, d.f. = 4

Priority of: remembering rules	1	2	3	4	5
AH	63 (15)	271 (65)	51 (12)	23 (6)	12 (3)
PP	21 (9)	135 (58)	43 (19)	22 (9)	9 (4)

$\chi^2 = 13.3$, $p < 0.01$, d.f. - 4

Priority of: understanding	1	2	3	4	5
AH	324 (77)	73 (17)	13 (3)	10 (2)	0 (0)
PP	177 (76)	32 (14)	10 (4)	7 (3)	4 (2)

$\chi^2 - 4.41$, $p < 0.30$, performed on collapsed ta e w th 4 & 5 combined, d f 3

Priority of: using a calculator	1	2	3	4	5
AH	8 (2)	36 (9)	207 (49)	91 (22)	78 (19)
PP	5 (2)	8 (3)	54 (23)	66 (28)	97 (42)

$\chi^2 = 62.38$, $p < 0.001$, performed on collapsed table with 1 & 2 combined, d.f. = 3

Are you worried or confident about maths GCSE?	worried	OK	confident
AH	158 (38)	225 (54)	35 (8)
PP	82 (35)	134 (58)	16 (7)

$\chi^2 = 1.1$, $p < 0.70$, d.f. = 2

Do maths lessons have a relaxed atmosphere?	often	sometimes	never
AH	94 (22)	257 (61)	67 (16)
PP	65 (28)	139 (60)	28 (12)

$\chi^2 = 3.5$, $p < 0.20$, d.f. = 2

Do you ever feel worried or anxious about work?	often	sometimes	never
AH	49 (12)	263 (63)	99 (24)
PP	22 (9)	146 (63)	52 (22)

$\chi^2 = 0.6$, $p < 0.80$, d.f. = 2

Chosen words to describe maths lessons	difficult	interesting	easy
AH	149 (36)	204 (49)	59 (14)
PP	104 (45)	72 (31)	28 (12)
$\chi^2 =$	5.3 $p < 0.05$	19.2 $p<0.001$	0.5 $p < 0.50$

Chosen words to describe maths lessons	fast	boring	relaxed
AH	100 (24)	170 (41)	143 (34)
PP	40 (17)	134 (58)	73 (31)
$\chi^2 =$	3 9 $p < 0.05$	17.5 $p <0.01$	0.50 $p< 0 50$

Chosen words to describe maths lessons	useful	similar	varied
AH	260 (62)	88 (21)	119 (28)
PP	101 (43)	47 (2)	73 (31)
$\chi^2 =$	2 9 p< 1	0 1 p <0 80	0 6 p < 0 50

Aspects students would like more of	bookwork	activities	practical	computer
AH	81 (19)	329 (78)	312 (74)	401 (96)
PP	71 (30)	141 (61)	147 (63)	216 (93)
$\chi^2 =$	10.5 $p < 0.01$	23.5 $p < 0.001$	9.0 $p < 0.01$	2.2 $p < 0.20$

Aspects students would like more of	variety	choice	teacher help
AH	295 (70)	360 (86)	305 (73)
PP	151 (65)	186 (80)	131 (56)
$\chi^2 =$	2.0 $p < 0.20$	3.8 $p < 0.10$	18.2 $p < 0.001$

Aspects students would like less of	bookwork	activities	practical	computer
AH	302 (72)	56 (13)	68 (16)	44 (11)
PP	122 (52)	47 (20)	40 (17)	33 (14)
$\chi^2 =$	25.1 $p < 0.001$	5.3 $p < 0.05$	0.1 $p < 0.80$	2.0 $p < 0.20$

Aspects students would like less of	variety	choice	teacher help
AH	74 (18)	27 (6)	55 (13)
PP	29 (12)	16 (7)	40 (17)
$\chi^2 =$	3.0 $p < 0.10$	0.0 $p < 1.0$	2.0 $p < 0.20$

Is it more important to remember similar work or think hard?	remember	think
AH	242 (58)	173 (41)
PP	90 (39)	142 (61)

$\chi^2 = 22.7$, $p < 0.001$, d.f. = 1

Years 9, 10 and 11 Questionnaire Qualitative Results
Amber Hill and Phoenix Park n and (%)

1. Write a sentence which you could use to describe your maths lesson to someone from another school

AH: 363 sentences from 420 students
PP: 200 sentences from 234 students

	AH (n)	PP (n)	AH (%)	PP (%)
very positive	7	7	2	3
positive	84	52	20	22
neutral	167	74	40	32
negative	98	66	23	28
very negative	7	1	2	0
no answer	57	34	14	15

$\chi^2 = 7.72$, $p < 0.05$, performed on collapsed table with very positive & positive, negative & very negative combined, d.f. = 2

	ANn	PPn	AH (%)	PP (%)	chi sq	p<
good atmosphere	47	40	11	17	4.5	0.05
bookwork	55	0	13	0	-	-
speed / pace	44	9	11	4	8 9	0 01
difficulty	78	23	19	10	8 8	0 01
structure	57	1	14	0	-	-
pressure / anxiety	32	4	8	2	-	-
teacher	73	22	17	9	7.2	0.01
interesting	29	16	7	7	7.7	0 01
boring	49	26	12	11	0.0	1.0
mixed boring & int	36	25	9	11	0 8	0.50
rules / equations	23	0	6	0	-	-
other students	10	4	2	2	-	-
noisy	16	28	4	12	15 9	0 001
variety	0	6	0	3	-	-
activities	0	14	0	6	-	-
independence	0	17	0	7	-	-

2. What do you like about maths lessons?

AH: 367 sentences from 420 students
PP: 207 sentences from 234 students

	AH (n)	PP (n)	AH (%)	PP (%)
very positive	8	8	2	3
positive	171	135	41	58
neutral	158	16	38	7
negative	47	48	11	21
very negative	7	0	2	0
no answer	29	27	7	12

$\chi^2 = 70.5$, $p < 0.001$, performed on collapsed table with negative & very negative combined, d.f. = 3

	AN n	PP n	AH (%)	PP (%)	chi-sq	p<
when we do activities	89	0	21	0	-	-
the teacher	51	15	12	6	5.44	0.02
relaxed atmosphere	31	40	7	17	14.7	0.001
enjoy the maths	20	32	5	14	16.3	0.001
computer work	49	17	12	7	3.2	0.10
learning things	36	14	9	6	1.4	0.30
(some) work is interesting	30	18	7	8	0.1	0.80
something other than maths	39	13	9	6	2.9	0.10
group work	26	13	6	6	0.1	0.80
independence	2	11	0	5	13.8	0.001
when I understand	24	4	6	2	-	-
working at own pace	17	4	4	2	-	-
lessons are fun	17	8	4	3	0.2	0.70
because I understand	6	3	1	1	-	-
useful	9	6	2	3	0.12	0.80
doing well	6	5	1	2	-	-
content area	11	6	3	3	0 0	1.0
variety	8	3	2	1	-	-
rules / formulae	8	1	2	0	-	-
starting a new subject	0	6	0	3	-	-
having to think	0	11	0	5	-	-
nothing	25	36	6	15	15 8	0.001
no answer	29	27	13	11	4 1	0.05

3. What do you dislike about maths lessons?

AH: 393 sentences from 420 students
PP: 204 sentences from 234 students

	AH (n)	PP (n)	AH (%)	PP (°)
very positive	0	0	0	0
positive	13	12	3	5
neutral	50	25	12	11
negative	296	166	71	71
very negative	29	1	7	0
no answer	32	30	8	13

$\chi^2 = 2.13$, $p < 0.50$, performed on collapsed table with very positive & positive, negative & very negative combined, d.f. = 2

	ANn	PPn	AH (%)	PP (%)	χ^2	p<
not understanding	90	37	21	16	22.9	0.001
the bookwork (AH) the activities (PP)	72	6	17	3	32	0.001
work is boring	61	38	15	16	6.4	0.01
work is all the same	57	5	14	2	-	-
the teacher	48	24	11	10	0.8	0.50
all of the work	33	23	8	10	3.0	0.10
too fast	35	5	8	2	-	-
content	28	5	7	2	-	-
pressure / anxiety	22	3	5	1	-	-
never learn anything	12	1	3	0	-	-
not enough activities	11	1	3	0	-	-
not enough computer wk	11	4	3	2	-	-
tests	24	2	6	0	-	-
homework	23	1	6	0	-	-
something other than maths	18	6	4	3	1.3	0.30
blackboard work	8	10	2	4	6 4	0 01
too noisy	2	12	0	5	-	-
time limits	0	12	0	5	-	-
not enough help	0	10	0	4	-	-
not knowing aim of inv	0	3	0	1	-	-
nothing	12	12	3	5	2 19	0.20
no answer	32	30	7	13	4 7	0.05

4. Describe the best maths lesson you have ever had

AH: 379 sentences from 421 students
PP: 167 sentences from 234 students

	ANn	PPn	AH (%)	PP (%)	χ^2	p<
coursework project (AH) a named activity (PP)	185	86	44	38	3.3	0.10
computer work	53	14	13	6	7.2	0.01
practical work	16	8	4	3	0 1	0.80
content	19	2	5	1	-	-
teacher was away	19	7	5	3	0.9	0.50
didn't do any maths	48	3	11	1	-	-
haven't had one	30	25	7	11	2.5	0.20
nice atmosphere	14	4	3	2	-	-
when I could understand	17	7	4	3	0.5	0.50
group work	6	1	1	0	-	-
got a good mark in test	11	0	3	0	-	-
when did a lot of work	4	0	1	0	-	-
when teacher nice / good	10	2	2	1	-	-
when not doing bookwork	7	0	2	0	-	-
exam work	8	0	2	0	-	-
when good pace	6	0	1	0	-	-
don't know	4	17	1	7	-	-
no answer	42	67	10	29	37.6	0.001

Years 9, 10 and 11 Questionnaire Quantitative Results
Amber Hill gender results n and (%)

Amber Hill n = 163

Are you a girl or a boy?

G	183 (44)
B	237(56)

Do you enjoy maths lessons?	always	sometimes	never
G	17 (9)	142 (78)	24 (13)
B	35 (15)	183 (77)	19 (8)

$\chi^2 = 5.13$, $p < 0.10$, d.f. = 2

Are you good, OK or bad at maths?	good	OK	bad
G	20 (11)	147 (80)	16 (9)
B	64 (27)	163 (69)	10 (4)

$\chi^2 = 18.6$, $p < 0.001$, d.f. = 2

Priority of: working fast	1	2	3	4	5
G	2 (1)	4 (2)	11 (6)	34 (19)	132 (72)
B	3 (1)	10 (4)	27 (11)	47 (20)	150 (63)

$\chi^2 = 5.70$, $p < 0.20$, performed on collapsed table with 1 & 2 combined, d.f. = 3

Priority of: getting lots done	1	2	3	4	5
G	3 (2)	7 (4)	48 (26)	105 (57)	20 (11)
B	17 (7)	21 (9)	62 (26)	109 (46)	28 (12)

$\chi^2 = 12.79$, $p < 0\ 01$, performed on collapsed table with 1 & 2 combined, d.f. = 3

Priority of: remembering rules	1	2	3	4	5
G	13 (7)	135 (74)	22 (12)	10 (6)	3 (2)
B	50 (21)	136 (57)	29 (12)	13 (5)	9 (4)

$\chi^2 = 18.37$, $p < 0\ \ 1$, performed on collapsed table with 4 & 5 combined, d.f. = 3

Priority of: understanding	1	2	3	4	5
G	161 (88)	20 (11)	1 (0)	1 (0)	0 (0)
B	163 (69)	53 (22)	12 (5)	9 (4)	0 (0)

Priority of: using a calculator	1	2	3	4	5
G	4 (2)	18 (10)	100 (55)	33 (18)	28 (15)
B	4 (2)	18 (8)	107 (45)	58 (25)	50 (21)

$\chi^2 = 6.47, p < 0.10$, performed on collapsed table with 1 & 2 combined, d.f. = 3

Are you worried or confident about maths GCSE?	worried	OK	confident
G	104 (57)	71 (39)	7 (4)
B	54 (23)	154 (65)	28 (12)

$\chi^2 = 51.0$ $p < 0.001$

Do maths lessons have a relaxed atmosphere?	often	sometimes	never
G	38 (21)	118 (65)	26 (14)
B	56 (24)	139 (59)	41 (17)

$\chi^2 = 1.6, p < 0.50$, d.f. = 2

Do you ever feel worried or anxious about work?	often	sometimes	never
G	33 (18)	128 (70)	21 (11)
B	16 (7)	135 (57)	78 (33)

$\chi^2 = 33.9, p < 0.001$, d.f. = 2

Chosen words to describe maths lessons	difficult	interesting	easy
G	88(48)	69 (38)	18 (10)
B	61 (26)	135 (57)	41 (17)
$\chi^2 =$	22.5 $p < 0.001$	15.3 $p < 0.001$	4.8 $p < 0.05$

Chosen words to describe maths lessons	fast	boring	relaxed
G	59 (32)	86 (47)	53 (29)
B	41 (17)	84 (35)	90 (38)
$\chi^2 =$	12.7 $p < 0.001$	5.7 $p < 0.02$	3.7 $p < 0.10$

Chosen words to describe maths lessons	useful	similar	varied
G	105 (57)	44 (24)	55 (30)
B	155 (65)	44 (19)	64 (27)
$\chi^2 =$	2.8 $p < 0.10$	1.9 $p < 0.20$	0.5 $p < 0.50$

Aspects students would like more of	bookwork	activities	practical	computer
G	37 (20)	140 (77)	127 (69)	173 (95)
B	44 (19)	189 (80)	185 (78)	228 (96)
χ^2 =	0.2 p <0.70	0.6 p < 0.50	4.1 p < 0.05	0.7 p < 0.50

Aspects students would like more of	variety	choice	teacher help
G	136 (74)	159 (87)	139 (76)
B	159 (67)	201 (85)	166 (70)
χ^2 =	2.6 p < 0.20	0.4 p <0.70	1.8 p < 0.20

Aspects students would like less of	bookwork	activities	practical	computer
G	131 (72)	30 (16)	38 (21)	23 (13)
B	171 (72)	26 (11)	30 (13)	21 (9)
χ^2 =	0.0 p <1.0	2.6 p < 0.20	5.0 p <0.05	1.5 p < 0.30

Aspects students would like less of	variety	choice	teacher help
G	27 (15)	10 (5)	16 (9)
B	47 (20)	17 (7)	39 (17)
χ^2 =	1.8 p < 0.20	0.5 p <0.50	5.4 p < 0.05

Is it more important to remember similar work or think hard?	remember	think
G	97 (53)	82 (45)
B	145 (61)	91 (38)

χ^2 = 2.2 p < 0.50, d.f. = 1

Years 9, 10 and 11 Questionnaire Quantitative Results
Phoenix Park gender results n and (%)

Phoenix Park n = 233

Are you a girl or a boy?	
G	114 (49)
B	119 (51)

Do you enjoy maths lessons?	always	sometimes	never
G	4(4)	96 (84)	14 (12)
B	9 (8)	93 (78)	17 (14)

Are you good, OK or bad at maths?	good	OK	bad
G	9 (8)	92 (81)	13 (11)
B	22 (18)	82 (69)	14 (12)

$\chi^2 = 6.0$, $p < 0.05$, d.f. = 2

Priority of: working fast	1	2	3	4	5
G	1 (1)	3 (3)	15 (13)	37 (32)	58 (51)
B	4 (3)	11 (9)	12 (10)	41 (34)	48 (40)

Priority of: getting lots done	1	2	3	4	5
G	7 (6)	22 (19)	50 (44)	29 (25)	6 (5)
B	15 (13)	19 (16)	45 (38)	29 (24)	8 (7)

$\chi^2 = 4.1$, $p < 0.50$, d.f. = 4

Priority of: remembering rules	1	2	3	4	5
G	9 (8)	74 (65)	18 (16)	10 (9)	3 (3)
B	12 (10)	61 (51)	25 (21)	12 (10)	6 (5)

$\chi^2 = 3.61$, $p < 0.50$ performed on collapsed table with 4 & 5 combined, d.f. = 3

Priority of: understanding	1	2	3	4	5
G	96 (84)	12 (11)	4 (4)	1 (1)	1 (1)
B	81 (68)	20 (17)	6 (5)	6 (5)	3 (3)

Priority of: using a calculator	1	2	3	4	5
G	1 (1)	3 (3)	26 (23)	37 (32)	47 (41)
B	4 (4)	5 (4)	28 (24)	29 (24)	50 (42)

Are you worried or confident about maths GCSE?	worried	OK	confident
G	51 (45)	62 (54)	1 (1)
B	31 (26)	72 (61)	15 (13)

Do maths lessons have a relaxed atmosphere?	often	sometimes	never
G	29 (25)	76 (67)	9 (8)
B	36 (30)	63 (53)	19 (16)

$\chi^2 = 5.5$, $p < 0.10$, d.f. = 2

Do you ever feel worried or anxious about work?	often	sometimes	never
G	16 (14)	82 (72)	9 (8)
B	6 (5)	64 (54)	43 (36)

$\chi^2 = 28.9$, $p < 0.001$, d.f. = 2

Chosen words to describe maths lessons	difficult	interesting	easy
G	60 (53)	38 (33)	11 (10)
B	44 (37)	34 (29)	17 (14)
$\chi^2 =$	5.8 $p < 0.02$	0.6 $p < 0.50$	1.2 $p < 0.30$

Chosen words to describe maths lessons	fast	boring	relaxed
G	21 (18)	76 (67)	31 (27)
B	19 (16)	58 (49)	42 (35)
$\chi^2 =$	0.2 $p < 0.70$	7.7 $p < 0.01$	1.8 $p < 0.20$

Chosen words to describe maths lessons	useful	similar	varied
G	50 (44)	22 (19)	34 (30)
B	51 (43)	25 (21)	39 (33)
$\chi^2 =$	0.0 $p < 1.0$	0.1 $p < 0.80$	0.2 $p < 0.80$

Aspects students would like more of	bookwork	activities	practical	computer
G	28 (25)	64 (56)	74 (65)	106 (93)
B	43 (36)	77 (65)	73 (61)	110 (92)
$\chi^2 =$	3.7 $p < 0.10$	1.8 $p < 0.20$	0.3 $p < 0.10$	0.0 $p < 1.0$

Aspects students would like more of	variety	choice	teacher help
G	68 (60)	90 (79)	67 (59)
B	83 (70)	96 (81)	64 (54)
$\chi^2 =$	2.6 $p < 0.20$	0.1 $p < 0.80$	0.6 $p < 0.50$

Aspects students would like less of	bookwork	activities	practical	computer
G	63 (55)	30 (26)	15 (13)	12 (11)
B	59 (50)	17 (14)	25 (21)	21 (18)
$\chi^2 =$	0.8 $p < 0.50$	5.2 $p < 0.05$	2.5 $p < 0.20$	2.4 $p < 0.20$

Aspects students would like less of	variety	choice	teacher help
G	18 (16)	8 (7)	18 (16)
B	11 (9)	8 (7)	22 (18)
$\chi^2 =$	2.3 $p < 0.20$	0.0 $p < 1.0$	0.3 $p < 0.70$

Is it more important to remember similar work or think hard?	remember	think
G	45 (39)	69 (61)
B	45 (38)	73 (61)

$\chi^2 = 0.1\ p < 0.80$, d.f. = 1

Year 9 Questionnaire Quantitative Results
Amber Hill and Phoenix Park n and (%)

Amber Hill n = 163
Phoenix Park n = 75

Are you a girl or a boy?	girl	boy
AH	69 (42)	88 (58)
PP	53(53)	47 (47)

Do you enjoy maths lessons?	always	sometimes	never
AH	21 (13)	123 (78)	13 (8)
PP	4 (4)	78 (78)	18 (18)

Are you good, OK or bad at maths?	good	OK	bad
AH	33 (21)	116 (74)	8 (5)
PP	17 (17)	74 (74)	8 (8)

$\chi^2 = 1.33$, $p < 0.70$, d.f. = 2

Priority of: working fast	1	2	3	4	5
AH	2 (1)	7 (5)	23 (15)	20 (13)	105 (67)
PP	2 (2)	5 (5)	12 (12)	39 (39)	39 (39)

Priority of: getting lots done	1	2	3	4	5
AH	7 (5)	11 (7)	43 (27)	83 (53)	13 (8)
PP	8 (8)	20 (20)	48 (48)	15 (15)	6 (6)

$\chi^2 = 40.8$, $p < 0.001$, d.f. = 4

Priority of: remembering rules	1	2	3	4	5
AH	27 (17)	96 (61)	15 (10)	8 (5)	8 (5)
PP	5 (5)	60 (60)	17 (17)	12 (12)	3 (3)

Priority of: understanding	1	2	3	4	5
AH	117 (75)	32 (20)	4 (3)	4 (3)	0 (0)
PP	81 (81)	8 (8)	6 (6)	1 (1)	1 (1)

Priority of: using a calculator	1	2	3	4	5
AH	4 (3)	11 (7)	72 (46)	39 (25)	31 (20)
PP	1 (1)	4 (4)	13 (13)	32 (32)	47 (47)

Are you worried or confident about maths GCSE?	worried	OK	confident
AH	65 (41)	81 (52)	11 (7)
PP	28 (28)	63 (63)	9 (9)

$\chi^2 = 4.8, p < 0.10$, d.f. = 2

Do maths lessons have a relaxed atmosphere?	often	sometimes	never
AH	27 (17)	99 (63)	31 (20)
PP	27 (27)	59 (59)	14 (14)

$\chi^2 = 4.1, p < 0.20$, d.f. = 2

Do you ever feel worried or anxious about work?	often	sometimes	never
AH	17 (11)	97 (62)	41 (26)
PP	4 (4)	61 (61)	28 (28)

Chosen words to describe maths lessons	difficult	interesting	easy
AH	57 (36)	75 (48)	27 (17)
PP	49 (49)	26 (26)	15 (15)
$\chi^2 =$	4.1 $p < 0.05$	12.1p <0 001	0.2 $p < 0.70$

Chosen words to describe maths lessons	fast	boring	relaxed
AH	44 (28)	66 (42)	46 (29)
PP	18 (18)	62 (62)	29 (29)
$\chi^2 =$	3.4 $p < 0.10$	9.7 p <0 1	0 0 p < 1 0

Chosen words to describe maths lessons	useful	similar	varied
AH	101 (64)	27 (17)	45 (29)
PP	34 (34)	18 (18)	25 (25)
$\chi^2 =$	22.5p < 0.001	0.0 p <1 0	0.4 $p < 0.70$

Aspects students would like more of	bookwork	activities	practical	computer
AH	32 (20)	120 (76)	108 (69)	151 (96)
PP	29 (29)	58 (58)	60 (60)	95 (95)
χ^2 =	2.5 $p < 0.20$	9.8 $p < 0.01$	2.1 $p < 0.20$	0.2 $p < 0.70$

Aspects students would like more of	variety	choice	teacher help
AH	100 (64)	134 (85)	123 (78)
PP	60 (60)	76 (76)	43 (43)
χ^2 =	0.4 $p < 0.70$	3.6 $p < 0.10$	33.4 $p < 0.01$

Aspects students would like less of	bookwork	activities	practical	computer
AH	118 (75)	29 (19)	34 (22)	23 (15)
PP	51 (51)	19 (19)	16 (16)	13 (13)
χ^2 =	15.8 $p < 0.001$	0.0 $p < 1.0$	1.3 $p < 0.30$	0.1 $p < 0.80$

Aspects students would like less of	variety	choice	teacher help
AH	40 (26)	15 (10)	23 (15)
PP	10 (10)	8 (8)	23 (23)
χ^2 =	9.3 $p < 0.01$	0.2 $p < 0.70$	2.9 $p < 0.10$

Is it more important to remember similar work or think hard?	remember	think
AH	89 (57)	68 (43)
PP	34 (34)	66 (66)

χ^2 =12.6, $p < 0.001$, d.f. = 1

Year 9 Questionnaire Qualitative Results
Amber Hill and Phoenix Park n and (%)

1. Write a sentence which you could use to describe your maths lesson to someone from another school

AH: 144 sentences from 157 students
PP: 82 sentences from 100 students

	AH (n)	PP (n)	AH (%)	PP (%)
very positive	0	2	0	2
positive	30	15	19	15
neutral	71	37	45	37
negative	41	27	26	27
very negative	2	1	1	1
no answer	13	18	8	18

$\chi^2 = 0.50$, d.f. = 2, $p < 0.80$, performed on collapsed table with very positive & positive, negative & very negative combined

Sentences referred to:

	ANn	PPn	AH (%)	PP (%)
speed / pace	20	1	13	1
difficulty	30	12	19	12
structure	19	0	12	0
teacher	31	9	20	9
bookwork	21	0	13	0
boring	18	12	12	12
rules / equations	15	0	10	0
good atmosphere	13	18	8	18
pressure / anxiety	7	3	5	3
noisy	8	10	5	10
mixed boring & int	7	14	5	14
interesting	6	4	4	4
variety	0	3	0	3
activities	0	5	0	5
independence	0	6	0	6

2. What do you like about maths lessons?

PP: 87 sentences from 100 students
AH: 151 sentences from 157 students

	AH (n)	PP (n)	AH (%)	PP (%)
very positive	3	1	2	1
positive	63	58	40	58
neutral	62	9	40	9
negative	22	19	14	19
very negative	1	0	0	0
no answer	6	13	4	13

$\chi^2 = 24.93$, d.f. = 2, $p < 0.001$, performed on collapsed table with positive & very positive, negative & very negative combined

	AN n	PP n	AH (%)	PP (%)
when we do activities	31	0	20	0
computer work	25	14	16	14
group work	15	9	10	9
enjoy the maths	13	15	8	15
learning things	11	5	7	5
relaxed atmosphere	12	10	8	10
something other than maths	16	6	10	6
(some) work is interesting	9	9	6	9
content area	9	3	6	3
the teacher	6	7	4	7
when I understand	6	2	4	2
lessons are fun	5	5	3	5
working at own pace	3	0	2	0
useful	3	0	2	0
because I understand	2	3	1	3
rules / formulae	3	0	2	0
variety	1	2	1	2
independence	0	6	0	6
starting a new subject	0	2	0	2
having to think	0	2	0	2
nothing	11	11	7	11
no answer	6	13	4	13

3. What do you dislike about maths lessons?

AH: 150 sentences from 157 students
PP: 86 sentences from 100 students

	AH (n)	PP (n)	AH (%)	PP (%)
very positive	0	0	0	0
positive	4	3	3	3
neutral	18	12	12	12
negative	122	71	78	71
very negative	6	0	4	0
no answer	7	14	5	14

	ANn	PPn	AH (%)	PP (%)
the bookwork (AH) the activities (PP)	29	3	19	3
not understanding	42	19	27	19
work is boring	22	21	14	21
the teacher	18	10	12	10
all of the work	14	9	9	9
content	14	3	9	3
too fast	10	2	6	2
pressure / anxiety	9	0	6	0
homework	17	1	11	1
work is all the same	12	4	8	4
tests	14	0	9	0
not enough help	7	1	5	1
something other than maths	5	3	3	3
not enough computer wk	3	1	2	1
blackboard work	0	3	0	3
never learn anything	2	0	1	0
too noisy	1	0	1	0
time limits	0	2	0	2
not knowing aim of inv	0	3	0	3
nothing	4	3	3	3
no answer	8	16	5	16

4. Describe the best maths lesson you have ever had

AH: 133 sentences from 157 students
PP: 64 sentences from 100 students

	ANn	PPn	AH (%)	PP (%)
coursework project (AH) a named process activity (PP)	47	32	30	32
computer work	30	12	19	12
practical work	3	3	2	3
content	13	1	8	1
teacher was away	5	2	3	2
didn't do any maths	24	1	15	1
haven't had one	4	5	3	5
nice atmosphere	7	1	5	1
group work	2	0	1	0
.got a good mark in test	6	0	4	0
when did a lot of work	3	0	2	0
when teacher nice / good	2	2	1	2
when not doing bookwork	2	0	1	0
exam work	2	0	1	0
don't know	0	8	0	8
no answer	14	36	9	36

Year 11 Questionnaire Quantitative Results
Amber Hill and Phoenix Park n and (%)

Amber Hill n = 100
Phoenix Park n = 58

Are you a girl or a boy?	girl	boy
AH	40 (40)	60 (60)
PP	29 (50)	29 (50)

Do you enjoy maths lessons?	always	sometimes	never
AH	17 (17)	75 (75)	8 (8)
PP	3 (5)	78 (78)	17 (17)

Are you good, OK or bad at maths?	good	OK	bad
AH	25 (25)	66 (66)	9 (9)
PP	4 (7)	44 (76)	10 (17)

Priority of: working fast	1	2	3	4	5
AH	1 (1)	2 (2)	3 (3)	20 (20)	74 (74)
PP	2 (3)	2 (3)	3 (5)	14 (24)	37 (64)

Priority of: getting lots done	1	2	3	4	5
AH	4 (4)	5 (5)	21 (21)	55 (55)	15 (15)
PP	4 (7)	6 (10)	22 (38)	22 (38)	4 (7)

Priority of: remembering rules	1	2	3	4	5
AH	12 (12)	71 (71)	13 (13)	4 (4)	0 (0)
PP	10 (17)	35 (60)	8 (14)	3 (5)	2 (4)

Priority of: understanding	1	2	3	4	5
AH	82 (82)	15 (15)	1 (1)	2 (2)	0 (0)
PP	39 (67)	13 (22)	3 (5)	2 (3)	1 (2)

Priority of: using a calculator	1	2	3	4	5
AH	1 (1)	8 (8)	62 (62)	18 (18)	11 (11)
PP	3 (5)	2 (3)	22 (38)	17 (29)	14 (24)

Are you worried or confident about maths GCSE?	worried	OK	confident
AH	29 (29)	57 (57)	13 (13)
PP	28 (48)	26 (45)	4 (7)

Do maths lessons have a relaxed atmosphere?	often	sometimes	never
AH	28 (28)	61 (61)	11 (11)
PP	10 (17)	38 (66)	10 (17)

$\chi^2 = 3.0, p < 0.30$, d.f. = 2

Do you ever feel worried or anxious about work?	often	sometimes	never
AH	11 (11)	62 (62)	26 (26)
PP	8 (14)	40 (69)	8 (14)

$\chi^2 = 3.1, p < 0.30$, d.f. = 2

Chosen words to describe maths lessons	difficult	interesting	easy
AH	23 (23)	47 (47)	14 (14)
PP	22 (38)	18 (31)	7 (12)

$\chi^2 =$ 4.0 $p < 0.05$ 4.6 $p < 0.05$

Chosen words to describe maths lessons	fast	boring	relaxed
AH	20 (20)	29 (29)	41 (41)
PP	11 (19)	34 (59)	17 (29)

$\chi^2 =$ 0.0 $p < 1.0$ 8.0 $p < 0.01$ 2.2 $p < 0.20$

Chosen words to describe maths lessons	useful	similar	varied
AH	61 (61)	19 (19)	30 (30)
PP	28 (48)	14 (24)	24 (41)

$\chi^2 =$ 2.4 $p < 0.20$ 0.6 $p < 0.50$ 2.1 $p < 0.20$

Aspects students would like more of	bookwork	activities	practical	computer
AH	21 (21)	78 (78)	80 (80)	94 (94)
PP	19 (33)	39 (67)	42 (72)	54 (93)
χ^2 =	2.7 $p < 0.20$	2.2 $p < 0.20$	1.2 $p < 0.30$	0.1 $p < 0.80$

Aspects students would like more of	variety	choice	teacher help
AH	74 (74)	85 (85)	66 (66)
PP	45 (78)	52 (90)	45 (78)
χ^2 =	0.3 $p < 0.70$	0.7 $p < 0.50$	2.4 $p < 0.20$

Aspects students would like less of	bookwork	activities	practical	computer
AH	71 (71)	11 (11)	13 (13)	10 (10)
PP	35 (60)	12 (21)	11 (19)	9 (16)
χ^2 =	1.9 $p < 0.20$	2.8 $p < 1.0$	1.0 $p < 0.50$	1.1 $p < 0.30$

Aspects students would like less of	variety	choice	teacher help
AH	15 (15)	4 (4)	18 (18)
PP	6 (10)	1 (2)	4 (7)

Is it more important to remember similar work or think hard?	remember	think
AH	58 (58)	38 (38)
PP	30 (52)	28 (48)

$\chi^2 = 1.1$, $p < 0.30$, d.f. = 1

Year 11 Qualitative Questionnaire Results
Amber Hill and Phoenix Park n and (%)

1. Write a sentence which you could use to describe your maths lesson to someone from another school

AH: 89 sentences from 100 students
PP: 51 sentences from 58 students

	AH (n)	PP (n)	AH (%)	PP (%)
very positive	7	3	7	5
positive	23	11	23	19
neutral	45	17	45	29
negative	13	20	13	35
very negative	1	0	1	0
no answer	11	7	11	12

χ^2 =9.9, $p < 0.01$, d.f. = 2 performed on collapsed table with very positive and positive combined, negative and very negative combined.

	ANn	PPn	AH (%)	PP (%)
structure of approach	20	1	20	2
interesting	17	1	17	2
good atmosphere	16	9	16	28
bookwork	17	0	17	29
mixed boring & int	16	2	16	14
pressure / anxiety	16	0	16	0
rules / equations	11	0	11	19
speed / pace	8	6	8	10
difficulty	8	8	8	14
other students	6	4	6	10
teacher	6	8	6	14
boring	3	8	3	14
noisy	1	1	1	2
variety	0	3	0	5
activities	0	4	0	7
independence	0	3	0	5

2. What do you like about maths lessons?

AH: 88 sentences from 100 students
PP: 53 sentences from 58 students

	AH (n)	PP (n)	AH (%)	PP (%)
very positive	3	2	3	4
positive	45	30	45	52
neutral	29	4	29	7
negative	9	15	9	26
very negative	2	0	2	0
no answer	12	7	12	12

	ANn	PPn	AH (%)	PP (%)
learning things	15	5	15	9
useful	3	0	3	0
enjoy the maths	3	4	3	7
(some) work is interesting	14	4	14	7
lessons are fun	4	0	4	0
relaxed atmosphere	10	13	10	22
working at own pace	4	2	4	3
when I understand	3	2	3	3
because I understand	11	0	11	0
the teacher	14	2	14	3
doing well	0	5	0	9
group work	4	2	4	3
computer work	1	2	1	3
content area	2	1	2	2
variety	1	0	1	0
rules / formulae	4	0	4	0
nothing	3	15	3	26
no answer	12	7	12	12
something other than maths	9	4	9	7
when we do activities	8	0	8	0
independence	0	1	0	2
starting a new subject	0	2	0	3
having to think	0	3	0	5

3. What do you dislike about maths lessons?

AH: 86 sentences from 100 students
PP: 50 sentences from 58 students

	AH (n)	PP (n)	AH (%)	PP (%)
very positive	0	0	0	0
positive	3	2	3	3
neutral	17	7	17	12
negative	57	41	57	71
very negative	9	0	9	0
no answer	14	8	14	14

	AN n	PP n	AH (%)	PP (%)
not understanding	16	11	16	19
work is all the same	14	0	14	0
the teacher	12	5	12	9
work is boring	12	5	12	9
bookwork	8	0	8	0
too fast	8	1	8	2
pressure / anxiety	8	3	8	5
all of the work	8	10	8	17
content	8	0	8	0
not enough computer wk	5	2	5	4
something other than maths	5	3	5	5
never learn anything	2	1	2	2
not enough activities (AH)	1	0	1	0
blackboard work	0	6	0	10
homework	2	0	2	0
tests	0	2	0	4
too noisy	0	1	0	2
activities are too long	0	1	0	2
time limits	0	1	0	2
not enough help	0	3	0	5
nothing	3	2	3	4
no answer	14	8	14	14

4. Describe the best maths lesson you have ever had

AH: 82 sentences from 100 students
PP: 43 sentences from 58 students

	ANn	PPn	AH (%)	PP (%)
coursework project (AH) a named process activity (PP)	36	23	36	40
computer work	9	2	9	4
practical work	6	3	6	5
content	1	0	1	0
teacher was away	10	1	10	2
didn't do any maths	14	1	14	2
haven't had one	11	10	11	17
nice atmosphere	6	8	6	14
when I could understand	12	7	12	12
group work	1	0	1	0
got a good mark in test	3	0	3	0
when did a lot of work	1	0	1	0
when teacher nice / good	4	0	4	0
when not doing bookwork	3	0	3	0
exam work	5	0	5	0
when good pace	5	0	5	0
don't know	4	14	4	24
no answer	18	15	18	26

Appendix 9 Year 11 Questionnaire Results

The year 11 questionnaire was entirely quantitative — students were not presented with sections in which they needed to write about their opinions. Pages 360 to 367 present the results for each school. The seven questions that produced significant differences between the schools are presented first. The remaining questions are clustered into the following sections: enjoyment, confidence, competition, views about learning, learning preferences and the nature of mathematics. Pages 368 to 375 present the results for the girls and boys at each school.

Year 11 Questionnaire Results
Amber Hill and Phoenix Park n and %

Amber Hill n = 129
Phoenix Park n = 73

A: Questions that produced significant differences between the two schools

1. Most of maths is just repeating the same sort of thing over and over again

n

	agree	disagree	total
AH	80	49	129
PP	32	41	73

$\chi^2 = 6.2$, d.f. = 1, $p < 0.02$

%

	agree	disagree
AH	62	38
PP	44	56

2. It is important in maths to: get more things right than other people

n

	agree	disagree	total
AH	29	100	129
PP	7	66	73

$\chi^2 = 5.3$, d.f. = 1, $p < 0.05$

%

	agree	disagree
AH	22	78
PP	9	91

3. It is important in maths to: find your own way of solving problems

n

	agree	disagree	total
AH	94	35	129
PP	64	9	73

$\chi^2 = 6.0$, d.f. = 1, $p < 0.02$

%

	agree	disagree
AH	73	27
PP	88	12

4. It is important in maths to: use your imagination

n

	agree	disagree	total
AH	84	45	129
PP	6	13	73

$\chi^2 = 6.6$, d.f. = 1, $p < 0.01$

%

	agree	disagree
AH	65	35
PP	82	18

5. It is important in maths to: think about different types of maths

n

	agree	disagree	total
AH	100	29	129
PP	66	7	73

$\chi^2 = 6.6$, d.f. = 1, $p < 0.02$

%

	agree	disagree
AH	78	22
PP	90	10

6. I feel pleased in maths when: I get everything right

		SA	A	D	SD	NH*	total
n:	AH	63	56	6	1	2	128
	PP	19	44	6	0	4	73

$\chi^2 = 10.9$ on collapsed table with D, SD and NH combined, d.f. = 2, $p < 0.01$

* NH = never happens

		SA	A	D	SD	NH
%:	AH	49	44	5	1	2
	PP	26	60	8	0	5

7. Do you think you are well behaved in maths lessons?

		always	most /time	hardly ever	never	total
n:	AH	45	81	2	0	128
	PP	16	51	3	3	73

$\chi^2 = 3.9$ on collapsed table with most, hardly & never combined, d.f. = 1, $p < 0.05$

		always	most /time	hardly ever	never	total
%:	AH	35	63	2	0	128
	PP	22	70	4	4	73

B: Non significant differences between schools

Enjoyment

1. I'd rather do other subjects than maths:

n

	agree	disagree	total
AH	53	76	129
PP	26	47	73

$\chi^2 = 0.6$, d.f. = 1, $p < 0.50$

%

	agree	disagree
AH	41	59
PP	36	64

2. I enjoy working on maths problems

n

	agree	disagree	total
AH	69	60	129
PP	44	29	73

$\chi^2 = 0.9$, d.f. = 1, $p < 0.50$

%

	agree	disagree
AH	53	47
PP	60	40

3. Maths is one of my favourite five subjects

n

	agree	disagree	total
AH	58	71	129
PP	40	33	73

$\chi^2 = 1.8$, d.f. = 1, $p < 0.20$

%

	agree	disagree
AH	45	55
PP	55	45

4. When did you enjoy maths the most?

		primary school	Y7 and 8 (AH SMP bklets)	Y9 - 11 (AH textbooks)	total
AH	n	48	45	35	128
	%	38	35	27	

		middle school (SMP bklets)	Y9 and 10 (PP project work)	Y11 (PP exam prep)	total
PP	n	31	22	20	73
	%	42	30	27	

$\chi^2 = 0.0$, d.f. = 2, $p < 1.0$

Confidence

1. Maths is easy for me

n

	agree	disagree	total
AH	23	106	129
PP	20	53	73

$\chi^2 = 2.5$, d.f. = 1, $p < 0.20$

%

	agree	disagree
AH	18	82
PP	27	73

2. I feel pleased in maths when: I find work easy

		SA	A	D	SD	NH*	total
n:	AH	32	75	17	0	4	128
	PP	18	42	8	4	1	73

$\chi^2 = 0.1$ on collapsed table with D, SD and NH combined, d.f. = 2, $p < 0.80$

		SA	A	D	SD	NH
%:	AH	25	59	13	0	3
	PP	25	58	11	5	1

3.Do you ever feel scared of your maths teacher?

		always	often	sometimes	never	total
n:	AH	9	1	26	92	128
	PP	3	1	12	57	73

$\chi^2 = 3.9$ on collapsed table with most, hardly & never combined, d.f. = 1, $p < 0.05$

		always	often	sometimes	never	total
%:	AH	7	1	20	72	128
	PP	4	1	16	78	73

Competition

1. I feel pleased in maths when: I finish before my friends

		SA	A	D	SD	NH	total
n:	AH	6	48	44	6	25	128
	PP	4	20	31	7	11	73

χ^2 = 4.1 on collapsed table with SA and A combined, d.f. = 3, p <0.30

		SA	A	D	SD	NH
%:	AH	5	27	42	10	15
	PP	5	37	34	5	19

2. I feel pleased in maths when: I am the only one who can answer a question

		SA	A	D	SD	NH	total
n:	AH	25	48	35	9	11	128
	PP	12	24	19	6	12	73

χ^2 = 3.1, d.f. = 4, p <0.70

		SA	A	D	SD	NH
%:	AH	20	38	27	7	9
	PP	16	33	26	8	16

Views about learning

1. It is important in maths to: answer questions the way the teacher wants you to

n

	agree	disagree	total
AH	79	50	129
PP	43	30	73

χ^2 = 0.1, d.f. = 1, p < 0 80

%

	agree	disagree
AH	61	39
PP	59	41

2. It is important in maths to: ask for help if you get stuck

n

	agree	disagree	total
AH	125	4	129
PP	71	2	73

%

	agree	disagree
AH	97	3
PP	97	3

3. Anyone can be successful at maths if they work hard enough

n

	agree	disagree	total
AH	94	35	129
PP	59	14	73

$\chi^2 = 1.6$, d.f. = 1, $p < 0.30$

%

	agree	disagree
AH	73	27
PP	81	19

4. Making mistakes helps you to learn

n

	agree	disagree	total
AH	118	11	129
PP	66	7	73

$\chi^2 = 0.1$, d.f. = 1, $p < 0.80$

%

	agree	disagree
AH	91	9
PP	90	10

Learning Preferences

1. I feel pleased in maths when: the teacher tells me exactly what to do

		SA	A	D	SD	NH	total
n.	AH	15	58	42	7	6	128
	PP	8	37	17	8	3	73

$\chi^2 = 2.7$ on collapsed table with SD and NH combined, d.f. = 3, $p <0.50$

		SA	A	D	SD	NH
%:	AH	12	45	33	5	5
	PP	11	51	23	11	4

2. I feel pleased in maths when: I solve a problem by working really hard

n:		SA	A	D	SD	NH*	total
	AH	50	66	6	0	6	128
	PP	29	35	3	0	6	73

χ^2 = 0.5 on collapsed table with D, SD and NH combined, d.f. = 2, p <0.80

%:		SA	A	D	SD	NH*
	AH	39	52	5	0	5
	PP	40	48	4	0	8

3. I feel pleased in maths when: I find work interesting

n:		SA	A	D	SD	NH	total
	AH	44	76	3	1	4	128
	PP	23	46	2	0	4	73

χ^2 = 0.5 on collapsed table with D, SD and NH combined, d.f. = 2, p <0.80

%:		SA	A	D	SD	NH
	AH	34	59	2	1	3
	PP	32	63	3	0	5

4. Do you prefer maths when:

you know exactly what to do and you can follow a clear step-by-step order *or* you can try different things out for yourself?

n

	steps	try out	total
AH	94	34	129
PP	47	26	73

χ^2 = 0.1, d.f. = 1, p < 0.80

%

	steps	try out
AH	73	27
PP	64	36

5. When you cannot work something out do you usually:

n:		give up	ask for help	try harder	total
	AH	19	81	28	128
	PP	14	52	7	73

$\chi^2 = 5.0$, d.f. = 2, $p < 0.10$

%:		give up	ask for help	try harder	total
	AH	15	63	22	128
	PP	19	71	10	73

Nature of mathematics

1. You don't need to understand maths as long as you can follow the rules

n

	agree	disagree	total
AH	30	99	129
PP	23	50	73

$\chi^2 = 1.6$, d.f. = 1, $p < 0.30$

%

	agree	disagree
AH	23	77
PP	32	68

2. It is important in maths to: remember lots of rules

n

	agree	disagree	total
AH	110	19	129
PP	59	14	73

$\chi^2 = 0.7$, d.f. = 1, $p < 0.50$

%

	agree	disagree
AH	85	15
PP	81	19

3. There are a lot of different things to learn in maths

n

	agree	disagree	total
AH	122	7	129
PP	69	4	73

%

	agree	disagree
AH	95	5
PP	95	5

Year 11 Questionnaire Results (gender)
Amber Hill and Phoenix Park n and %

1. Maths is easy for me

AH

n	agree	disagree	total
b	19	54	73
g	4	52	56

%	agree	disagree
b	26	74
g	7	93

PP

n	agree	disagree	total
b	15	33	48
g	5	20	25

%	agree	disagree
b	31	69
g	20	80

2. Anyone can be successful at maths if they work hard enough

AH

n	agree	disagree	total
b	62	11	73
g	32	24	56

%	agree	disagree
b	85	15
g	57	43

PP

n	agree	disagree	total
b	38	10	48
g	21	4	25

%	agree	disagree
b	79	21
g	84	16

$\chi^2 = 12.4$, d.f. = 1, $p < 0.001$

3. It is important in maths to: answer questions the way the teacher wants you to

AH

n	agree	disagree	total
b	51	22	73
g	27	28	56

%	agree	disagree
b	70	30
g	49	51

PP

n	agree	disagree	total
b	25	23	48
g	20	5	25

%	agree	disagree
b	52	48
g	80	20

$\chi^2 = 5.7$, d.f. = 1, $p < 0.02$

4. It is important in maths to: find your own way of solving problems

AH

n

	agree	disagree	total
b	48	25	73
g	46	9	56

%

	agree	disagree
b	66	34
g	84	16

PP

n

	agree	disagree	total
b	41	7	48
g	23	2	25

%

	agree	disagree
b	85	15
g	92	8

$\chi^2 = 5.1$, d.f. = 1, $p < 0.05$

5. It is important in maths to: think about different types of maths

AH

n

	agree	disagree	total
b	52	21	73
g	48	7	56

%

	agree	disagree
b	71	29
g	87	13

PP

n

	agree	disagree	total
b	44	4	48
g	23	3	25

%

	agree	disagree
b	92	8
g	92	8

$\chi^2 = 4.7$, d.f. = 1, $p < 0.05$

6. There are a lot of different things to learn in maths

AH

n

	agree	disagree	total
b	66	7	73
g	56	0	56

%

	agree	disagree
b	90	10
g	100	0

PP

n

	agree	disagree	total
b	45	3	48
g	24	1	25

%

	agree	disagree
b	94	6
g	96	4

7. I enjoy working on maths problems

AH

n

	agree	disagree	total
b	33	41	73
g	36	19	56

%

	agree	disagree
b	45	55
g	64	34

$\chi^2 = 5.5$, d.f. = 1, $p < 0.02$

PP

n

	agree	disagree	total
b	27	21	48
g	17	8	25

%

	agree	disagree
b	56	44
g	68	22

$\chi^2 = 0.9$, d.f. = 1, $p < 0.50$

8. It is important in maths to: get more things right than other people

AH

n	agree	disagree	total
b	21	52	73
g	7	48	56

%	agree	disagree
b	29	71
g	13	87

PP

n	agree	disagree	total
b	7	41	48
g	0	25	25

%	agree	disagree
b	14	86
g	0	100

$\chi^2 = 4.7$, d.f. = 1, $p < 0.05$

9. I'd rather do other subjects than maths:

AH

n	agree	disagree	total
b	30	43	73
g	23	33	56

%	agree	disagree
b	41	59
g	41	59

$\chi^2 = 0.0$, d.f. = 1, $p < 1.0$

PP

n	agree	disagree	total
b	16	32	48
g	10	15	25

%	agree	disagree
b	33	67
g	40	60

$\chi^2 = 0.3$, d.f. = 1, $p < 0.70$

10. Maths is one of my favourite five subjects

AH

n	agree	disagree	total
b	34	39	73
g	24	32	56

%	agree	disagree
b	46	54
g	43	57

$\chi^2 = 0.2$, d.f. = 1, $p < 0.70$

PP

n	agree	disagree	total
b	28	20	48
g	12	13	25

%	agree	disagree
b	58	42
g	48	52

$\chi^2 = 0.7$, d.f. = 1, $p < 0.50$

11. When did you enjoy maths the most?

AH		primary school	Y7 and 8 (AH SMP bklets)	Y9 - 11 (AH textbooks)	total
n	b	26	25	22	73
	g	22	20	13	56
%	b	36	34	30	
	g	40	36	24	

PP		middle school (SMP bklets)	Y9 and 10 (PP project work)	Y11 (PP exam prep)	total
n	b	21	12	15	48
	g	10	10	5	25
%	b	44	25	31	
	g	40	40	20	

12. I feel pleased in maths when: I find work easy

n		SA	A	D	SD	NH	total
AH	b	14	45	11	0	3	73
	g	18	30	6	0	1	56
PP	b	11	29	5	3	0	48
	g	7	13	3	1	1	25

%		SA	A	D	SD	NH
AH	b	19	62	15	0	4
	g	33	55	11	0	2
PP	b	23	60	10	6	0
	g	28	52	12	4	4

13. I feel pleased in maths when: I finish before my friends

n		SA	A	D	SD	NH	total
AH	b	2	29	25	2	15	73
	g	3	19	19	4	10	56
PP	b	4	13	19	4	8	48
	g	0	7	12	3	3	25

%		SA	A	D	SD	NH
AH	b	3	40	34	3	21
	g	5	35	35	7	18
PP	b	8	27	40	8	17
	g	0	28	48	12	12

14. I feel pleased in maths when: I am the only one who can answer a question

n		SA	A	D	SD	NH	total
AH	b	13	25	19	9	7	73
	g	12	23	16	0	4	56
PP	b	9	15	13	3	8	48
	g	3	9	6	3	4	25

%		SA	A	D	SD	NH
AH	b	18	34	26	12	10
	g	22	42	29	0	7
PP	b	19	31	27	6	17
	g	12	36	24	12	16

15. Most of maths is just repeating the same sort of thing over and over again

AH

n	agree	disagree	total
b	47	26	73
g	33	23	56

%	agree	disagree
b	64	36
g	41	59

$\chi^2 = 0.4$, d.f. = 1, $p < 0.70$

PP

n	agree	disagree	total
b	20	28	48
g	12	13	25

%	agree	disagree
b	42	58
g	48	52

$\chi^2 = 0.3$, d.f. = 1, $p < 0.70$

16. You don't need to understand maths as long as you can follow the rules

AH

n	agree	disagree	total
b	17	56	73
g	13	43	56

%	agree	disagree
b	23	77
g	23	77

$\chi^2 = 0.0$, d.f. = 1, $p < 1.0$

PP

n	agree	disagree	total
b	14	34	48
g	9	16	25

%	agree	disagree
b	29	71
g	36	64

$\chi^2 = 0.4$, d.f. = 1, $p < 0.70$

17. It is important in maths to: use your imagination

AH

n	agree	disagree	total
b	45	28	73
g	39	16	56

%	agree	disagree
b	62	38
g	71	29

$\chi^2 = 1.2$, d.f. = 1, $p < 0.30$

PP

n	agree	disagree	total
b	40	8	48
g	20	5	25

%	agree	disagree
b	83	17
g	80	20

18. It is important in maths to: remember lots of rules

AH

n

	agree	disagree	total
b	63	10	73
g	46	9	56

%

	agree	disagree
b	86	14
g	84	16

$\chi^2 = 0.2$, d.f. = 1, $p < 0.70$

PP

n

	agree	disagree	total
b	40	8	48
g	19	6	25

%

	agree	disagree
b	83	17
g	76	24

$\chi^2 = 0.6$, d f. = 1, $p < 0.50$

19. Making mistakes helps you to learn

AH

n

	agree	disagree	total
b	63	10	73
g	55	1	56

%

	agree	disagree
b	86	14
g	98	2

PP

n

	agree	disagree	total
b	43	5	48
g	23	2	25

%

	agree	disagree
b	89	11
g	92	8

20. It is important in maths to: ask for help if you get stuck

AH

n

	agree	disagree	total
b	70	3	73
g	54	1	56

%

	agree	disagree
b	96	4
g	98	2

PP

n

	agree	disagree	total
b	46	2	48
g	25	0	25

%

	agree	disagree
b	96	4
g	100	0

21. I feel pleased in maths when: I find work interesting

n		SA	A	D	SD	NH	total
AH	b	21	44	3	1	4	73
	g	23	32	0	0	0	56
PP	b	13	31	1	0	3	48
	g	8	15	1	0	1	25

%		SA	A	D	SD	NH
AH	b	29	60	4	1	5
	g	42	58	0	0	0
PP	b	27	65	2	0	6
	g	32	60	4	0	4

22. I feel pleased in maths when: the teacher tells me exactly what to do

n		SA	A	D	SD	NH	total
AH	b	8	36	22	2	5	73
	g	7	22	20	5	1	56
PP	b	5	23	13	6	1	48
	g	3	14	4	2	2	25

%		SA	A	D	SD	NH
AH	b	11	49	30	3	7
	g	13	40	36	9	2
PP	b	10	48	27	13	2
	g	12	56	16	8	8

23. I feel pleased in maths when: I solve a problem by working really hard

n		SA	A	D	SD	NH	total
AH	b	19	38	4	0	2	73
	g	21	28	2	0	4	56
PP	b	19	23	3	0	3	48
	g	10	12	0	0	3	25

%		SA	A	D	SD	NH
AH	b	40	52	5	0	3
	g	38	51	4	0	7
PP	b	40	48	6	0	6
	g	40	48	0	0	12

24. Do you prefer maths when:

you know exactly what to do and you can follow a clear step-by-step order *or you* can try different things out for yourself

AH

n	steps	try out	total
b	51	22	73
g	43	12	56

$\chi^2 = 1.1$, d.f. = 1, $p < 0.30$

%	steps	try out
b	70	30
g	78	22

PP

n	steps	try out	total
b	31	17	48
g	16	9	25

$\chi^2 = 0.0$, d.f. = 1, $p < 1.0$

%	steps	try out
b	65	35
g	64	36

25. When you cannot work something out do you usually:

n		give up	ask for help	try harder	total
AH	b	10	41	22	73
	g	9	40	6	55
PP	b	9	33	6	48
	g	5	19	1	25

%		give up	ask for help	try harder
AH	b	14	56	30
	g	16	73	11
PP	b	19	69	13
	g	20	76	4

26. Do you think you are well behaved in maths lessons?

n		always	often	sometimes	never	total
AH	b	24	47	2	0	73
	g	21	34	0	0	56
PP	b	10	34	3	1	48
	g	6	17	0	2	25

%		always	often	sometimes	never	total
AH	b	33	64	3	0	73
	g	38	62	0	0	56
PP	b	21	71	6	2	48
	g	24	68	0	8	25

27. Do you ever feel scared of your maths teacher?

n		always	often	sometimes	never	total
AH	b	7	0	10	56	73
	g	2	1	16	36	56
PP	b	0	1	6	41	48
	g	0	2	7	16	25

%		always	often	sometimes	never	total
AH	b	10	0	14	77	73
	g	4	2	30	65	56
PP	b	0	2	13	85	48
	g	0	8	28	64	25

Appendix 10 Year 9 and 10 Context Questions

The seven context questions that were given to students in year 9 are presented in the following order:

Chocolate Splits
Tug of War

Fractions
Penalties
Planting Seeds

Cutting Wood
Fashion Workshop

In year 10 the students were given all of the above plus the two questions presented at the end of appendix 10:

Fences and
The Letter T

All of the questions have been reduced in size.

Name: ______________________________ Maths teacher: ____________________

Chocolate splits

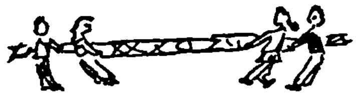
Paul and Sarah split a bar of chocolate.

Paul finds he has 3 more pieces than Sarah so he gives Sarah another one of his pieces.

How many more pieces of chocolate has Paul got than Sarah now?

Explain how you worked this out.

Tug of war



The Red team and the Blue team have a tug of war.

At first Red has three more people than Blue.

Then one person from Red changes sides.

By how many people is the Red team bigger
than the Blue team now?

Explain how you worked this out.

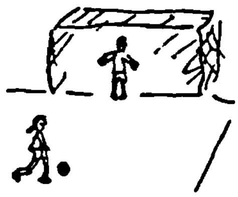
Fractions

Which fraction is biggest:

$\frac{10}{14}$ or $\frac{16}{21}$?

Explain how you worked this out.

Penalties



Two girls, Julie and Sue, both play football in the school team.

Last season they both took penalties.

Julie scored 7 out of the 10 penalties she took.
Sue scored 10 out of the 15 penalties she took.

Who is better at taking penalties?

Explain how you worked this out.

Planting Seeds

Cofi and Matt are planting seeds in their window boxes.

They both decide to try a different plant food.

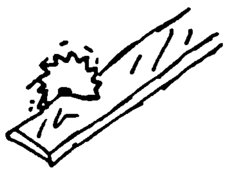
Cofi puts 12 seeds in his window box and gives them some plant food, 9 of them grow into plants.

Matt puts 18 seeds in his window box and gives them some plant food, 14 of them grow into plants.

Who has the best plant food, Cofi or Matt?

Explain how you worked out your answer

Cutting Wood



A small wood shop has lots of planks of wood which are all 20m long.

A customer needs the following size planks of wood:

9m, 8m, 7m, 7m, 5m, 5m, 4m, 4m, 4m, 4m, 4m, 4m,
3m, 3m, 3m, 3m, 3m.

Say how the shop could cut the 20m planks into the sizes the customer wants.

You should try not to waste any of the 20m planks.

Write down all of the decisions you make when you are working out your results.

Fashion Workshop

Four people, Jane, Susan, Ramesh and Darren have to do some important work for a deadline.

They have got 22 hours each to do the work and they cannot share any of the jobs.

Work out who can do which jobs.

Show all of your working out and write down all of the decisions you make.

Packing

socks	2 hrs
t - shirts	3 hrs
shirts	4 hrs
trousers	7 hrs
jumpers	3 hrs

Sewing

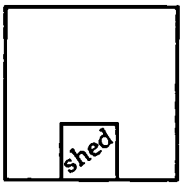
skirts	10 hrs
jeans	5 hrs
jackets	7 hrs
coats	7 hrs
shorts	5 hrs
waistcoats	7 hrs

Other Jobs

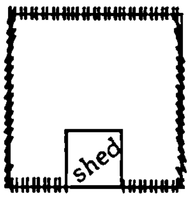
opening letters	3 hrs
answering letters	5 hrs
filing	3 hrs
deliveries to Birmingham	9 hrs
deliveries to London	8 hrs

Fences

Kerry owns a square piece of land which has a small square based shed built onto it:



There is a fence all the way round the land:



The sides of the square of land are 3 times the size of the sides of the shed.

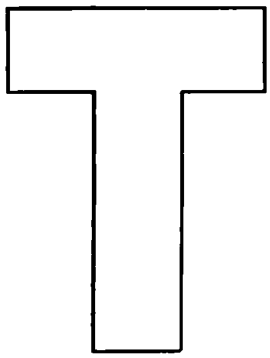
The fence is 22m long.

What area of land has Kerry got left which she could use for planting?

Explain how you worked this out.

The Letter 'T'

In this diagram the long sides are all three times as long as the short sides:



If the perimeter of the diagram is 28cm what is the area?

Appendix 11 The Architectural Activity

The architecture activity is presented in the following order:

The A3 scale plan (reduced)

The students' task sheet which told them what they needed to do (reduced).

Council regulations concerning the design of houses (reduced).

The formula sheet.

The students response sheets (reduced).

Students were also given a small 4 x 3 x 2 cm model of the house.

TASK SHEET

Your job in the next 50 mins or so is to complete the 3 architect report sheets.

In the 1st and 2nd report sheets you need to

- say whether the house has passed the council rules about roof space and roof angles

- say why you think the council has the rules

- say whether you think the rules are sensible or not

In the 3rd report sheet you need to give the size that the windows should be on the scale plan.

Model House Scale 1mm:0.2m

ROOF DESIGN

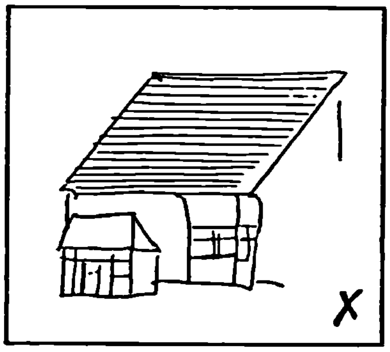
SPAN 11

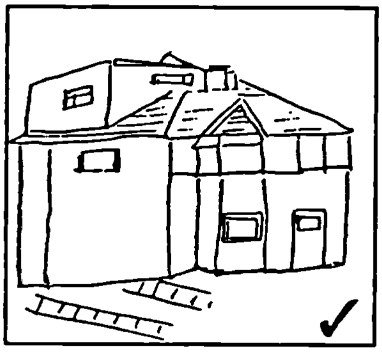
INTRODUCTION

1. The council has no objection to the design of rooves or roof additions, provided that the design is well mannered, discreet and sensitively executed. Applicants will be asked to locate the larger elements of roof additions on rear elevations, in order to protect front and side elevations from substantial elevation.

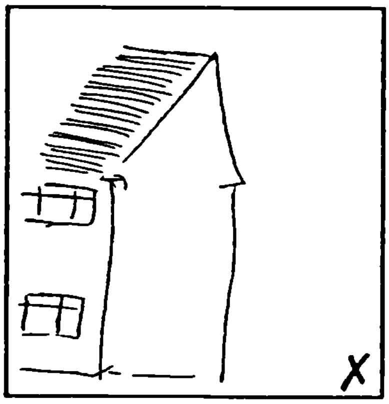
2. There is a tendency to provide more accomodation in roof spaces than is environmentally acceptable. In such cases it may be preferable to construct an extension at the side or rear of the building instead.

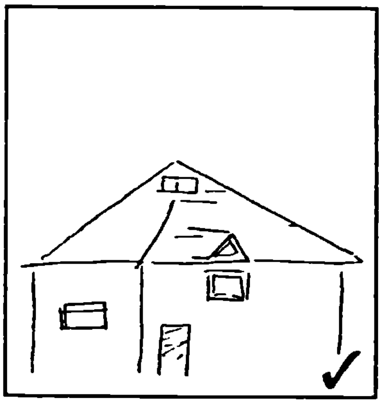
3. RULE: The space taken up by the roof of a house, a roof addition or a roof extension, must not be more than 70% of the space taken up by the house.

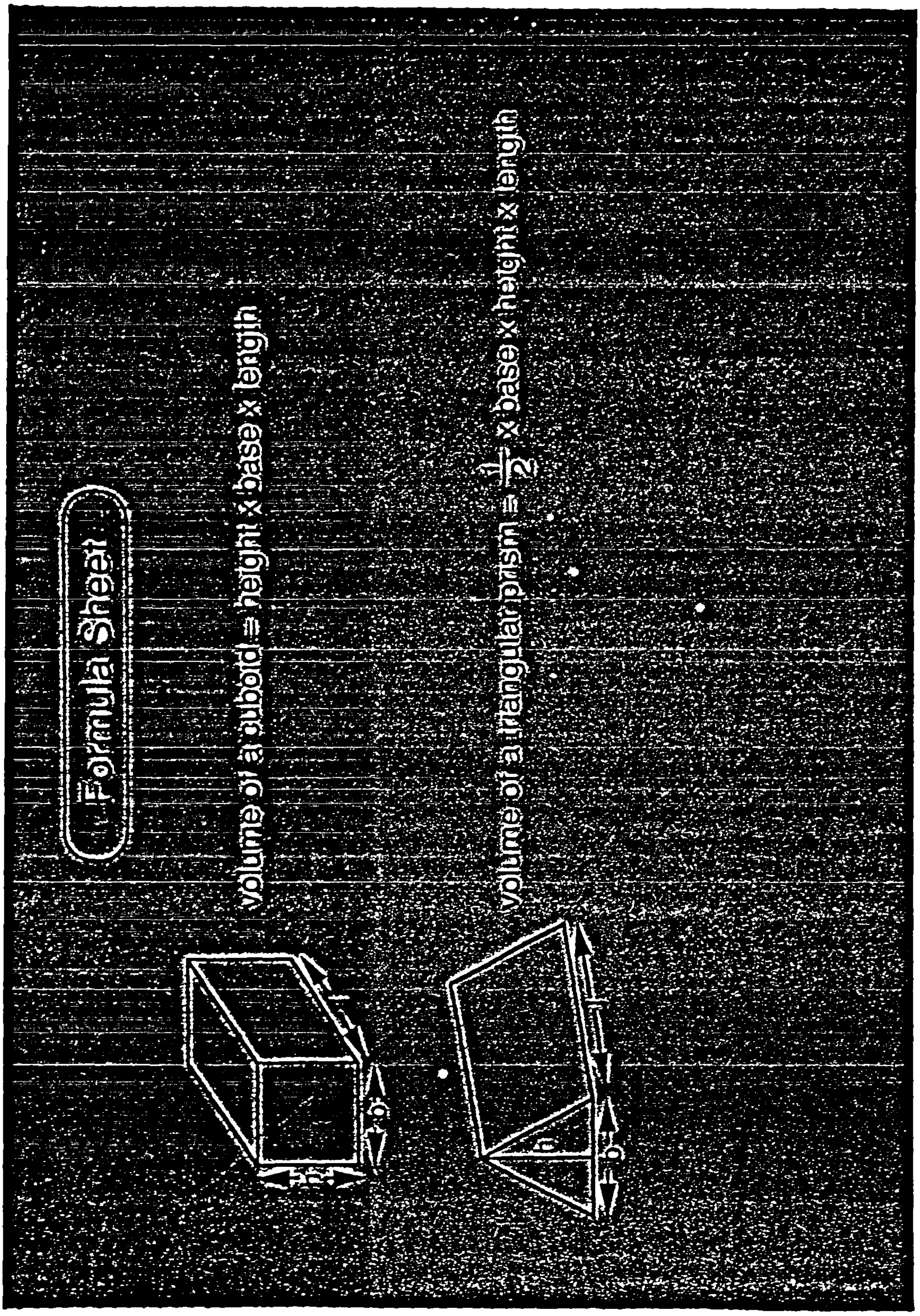




4. RULE: The angle made by the top of triangular rooves must be 70° or more.






Formula Sheet
volume of a cuboid = height x base x length
volume of a triangular prism = 1/2 x base x height x length

Architecht's Report by ....

1. Does the house pass the roof space rule yes / no

2. Reason and all calculations

3. The council has this rule because

4. I think this is a good / bad rule

5. My reason is

Architecht's Report by ....

6. Does the house pass the roof angle rule yes / no

7. Reason and/or drawings

8. The council has this rule because

9. I think this is a good / bad rule
10. My reason is

Appendix 12 Standardised NFER scores for students taking the Architecture activity

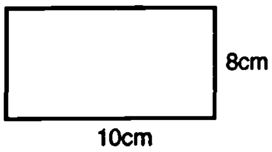
	-1.5 to 1	-1 to -0.5	-0.5 to 0.2	0.2 to 0.8	0 8 to 1,5	n
Amber Hill	2	12	14	10	5	43
Phoenix Park	14	12	12	3	1	42

$\chi^2 = 15.6$, d.f. = 4, $p < 0.01$*

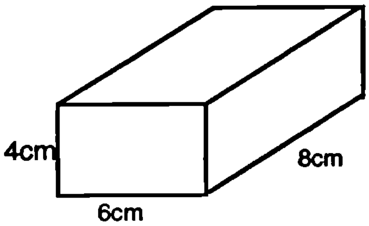
*NB Three of the cell contents are less than 6.

Appendix 13 Architecture Short Test (reduced)

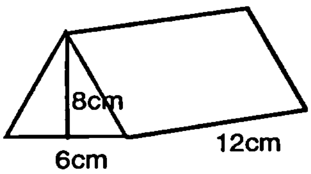
1. Find the area of this rectangle:



2. Find the volume of this cuboid:



3. Find the volume of this triangular prism:

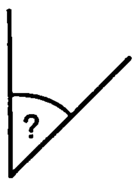


4. At a school there are 1125 pupils, 675 are girls.
   What percentage of the pupils are girls?

5. A 500 metre road is shown on a map.
   The map has a scale of 1cm = 50 metres.
   How many centimetres long is the road on the map?

6. An 80 metre road is shown on a map.
   The road is shown on the map as 2cm long.
   What is the scale used in the map?

7. Without using a protractor or angle indicator say whether the angle shown below is



a) 20°
b) 45°
c) 90° or
d)120°

Appendix 14 Planning a Flat Activity

'Planning a flat' is presented in the following order:

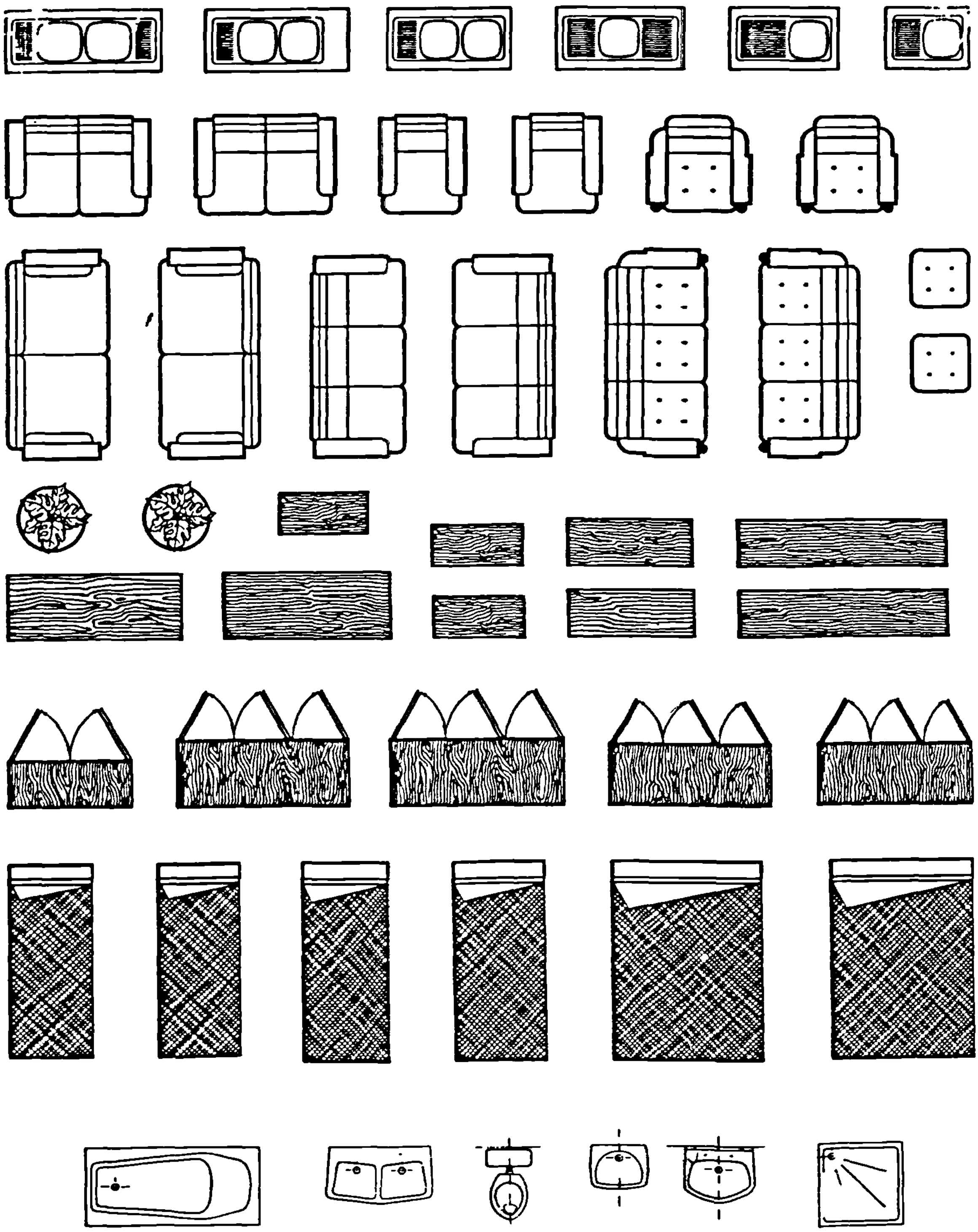
The A3 flat plan (reduced).

Sheet of furniture (reduced) which students could use to trace or copy the diagrams if they wished.

Planning a flat questions (reduced).

Planning a Flat

P 25



Planning a Flat

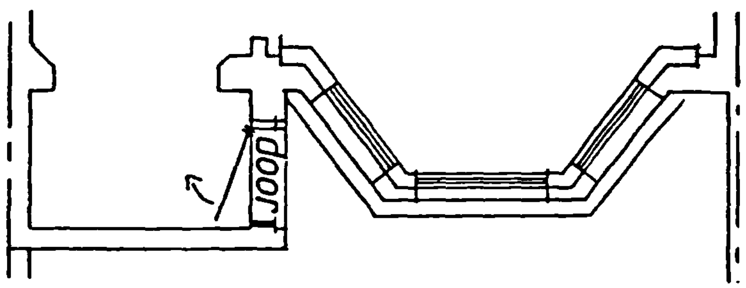
Questions

1. Carpet costs about £7.99 per square metre.

a) *Roughly* how much would it cost to carpet all of the flat?
Show all of your working out.

b) If you needed a bank loan to pay for the carpet, how much would you borrow from the bank? Explain your decision.

2. Street doors have to open to an angle of at least 115°. Will the street door of the flat pass this regulation? (The door is shown on the diagram below).



You <u>must not</u> use an angle indicator - explain how you have worked out your answer.

Appendix 15: Standardised NFER scores for students taking the Planning a Flat activity

	-2.4 to -1.8	-1.8 to -1.2	-1.2 to 0.6	0.6 to 0.0	0.0 to 1.2	n
Amber Hill	6	16	28	21	13	84
Phoenix Park	15	32	18	10	5	80

Collapsed table with last 2 columns combined

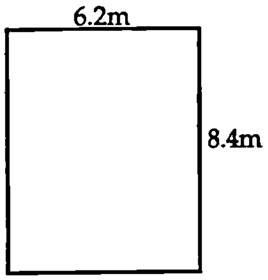
	-2.4 to -1.8	-1.8 to -1.2	-1.2 to 0.6	0.6 to 0.0	n
Amber Hill	6	16	28	34	84
Phoenix Park	15	32	18	15	80

$\chi^2 = 18.65$, d.f. = 3, $p < 0.001$

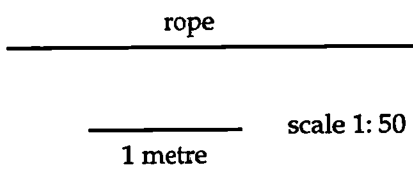
Appendix 16 Planning A Flat Short Test (reduced)

Name________________________ Maths teacher ____________________

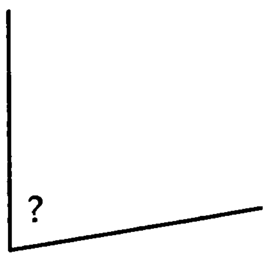
1. What is the area of this rectangle?



2. How many metres long is this piece of rope?



3. Is this angle more or less than 60°? Do not use an angle indicator.



4. A carpet has an area of $22.25m^2$

$1.42m^2$ of the carpet is blue

What percentage of the carpet is blue?

Appendix 17 Long Term Learning Tests

The long term learning tests are presented in the following order:

Test	**Given to**
Rates	Amber Hill year 9
Mixing and Sharing	Amber Hill year 10
The 142857 times table	Phoenix Park year 9
Estimating	Phoenix Park year 10

Rates

Please show all of your working, use the back of the paper if you need to.

1. Water comes out of a fountain at a rate of 400 litres per minute.

a) How much water comes out of the fountain in 15 minutes?

b) How long is it before 600 litres of water comes out of the fountain?

2. A factory makes 320 metres of tubing in 80 seconds.

At what rate does the factory make tubing in metres / second?

3. If £15 is worth $22 work out

a) the number of pounds per dollar

b) the number of dollars per pound.

4. London to Nottingham is approximately 122 miles.

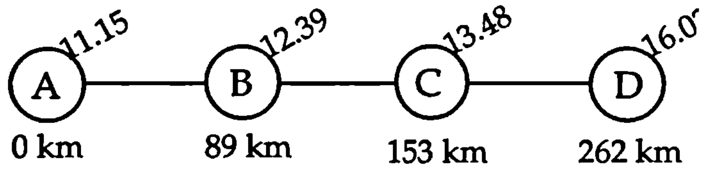
The 10.08 train from London arrives in Nottingham at 11.52.

Calculate the average speed of the train in miles per hour.

5. A sugar solution contains 43.2g of sugar per litre.

How much sugar is there in 0.7 litres of solution?

6. A train leaves A at 11.15. The map below shows when it gets to the other stations and the distance of each station from A.



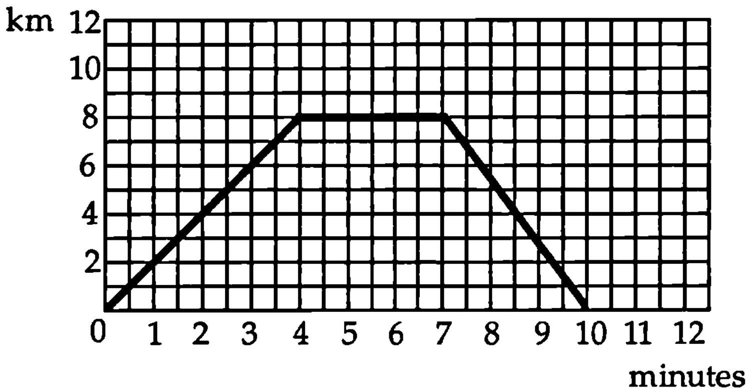
Calculate the average speed of the train in km per hour between:

a) A and B

b) B and C

c) C and D

7. This is a time distance graph for a train.



a) What is the train's average rate of increase in speed?

b) What is the train's average rate of decrease in speed?

8. A car travelling at 80km per hour uses up petrol at a rate of 6 litres per 100km.

Calculate the rate of petrol consumption in litres per hour.

Mixing and Sharing

Please show all of your working, use the back of the paper if you need to.

1. Jim is using a cleaning fluid. He needs to dilute the fluid with water in the ratio 1: 5

a) How much water will he need with 20 ml of fluid?

b) Jim uses 150 ml of water, how much fluid has he used?

c) If Jim needs 240 ml of liquid all together, how much water and how much cleaning fluid should he use?

2. Sue mixes blue and white paint in the ratio 2: 3

a) How much blue should be mixed with 7 litres of white?

b) How much white should be mixed with 3 litres of blue?

c) Suggest a ratio that Sue could use if she wanted a lighter shade of blue.

3. A football and a hockey team share a pitch. They hire the pitch for £360 a year.

The footballers use it for 5 months, the hockey players use it for 7 months

How much should they each pay ?

4. The profit from a record is divided between the artist, the manager and the record company in the ratio 7: 4: 3. The profit from the record is £4,200.

How much does the artist, the record company and the manager get?

5. Sara, Cam and Marco deliver some leaflets. Sara delivers 100, Cam delivers 300 and Marco delivers 200. They earn £100 between them. How much should they each get?

The 142857 times table!

The table below shows the first 5 rows of the times table for 142857.

	142857
x 1	142857
x 2	285714
x 3	428571
x 4	571428
x 5	714285

1) What do you notice about the numbers in the table?

2) Fill in 142857 x 6 without using a calculator:

	142857
x 6	

3) Explain how you got your answer

4) The table below shows the first 10 rows of the times table.

(You will need to fill in your answer from page 1 in row 6).

	142857
x 1	142857
x 2	285714
x 3	428571
x 4	571428
x 5	714285
x 6	
x 7	999999
x 8	1142856
x 9	1285713
x 10	1428570

Look at the pattern of numbers and try and find the next two rows without a calculator.

	142857
x 11	
x 12	

5) Now change the following fractions into decimals, **without** using a calculator:

$\frac{1}{7} =$

$\frac{2}{7} =$

$\frac{3}{7} =$

What do you notice?

6) Work out which fraction is biggest $\frac{3}{7}$ or $\frac{4}{9}$ without using a calculator.

Show all of your working.

Estimating

1) Estimate the length of these lines in centimetres:

____ my answer ______

______________________________________ my answer ______

___________________________ my answer ______

2) What method did you use to help you estimate the lengths of the lines?

3) In a school fair Sally and Tom have to guess the weight of 2 different bags of marbles.

Sally guesses the big bag. The bag weighs 750g.

Sally guesses that it weighs 730g.

Tom guesses the small bag. The bag weighs 64g.

He guesses it weighs 55g.

Who is better at estimating weight?

4) Explain how you worked out your answer.

5) In a school skiing competition two classes, 9Y and 10G, take part in two races. The first race is in the morning, the second race is in the afternoon.

Here are the results:

Name	Class	Male/ female	Morning race time	Afternoon race time
Peter	10G	M	7.50	8.20
Sally	9Y	F	6.20	7.20
Colin	9Y	M	7.00	8.10
Paula	10G	F	5.46	6.50
Tony	9Y	M	7.06	8.04
Anne	9Y	F	7.20	8.51
Jenny	10G	F	4 22	6.12
Osé	10G	M	7.12	8.14
Alan	9Y	M	7.05	8.02
Jimmy	9Y	M	5.14	7.52
Sue	10G	F	6.16	7.15
Trudy	10G	F	5.00	7.02
Karl	9Y	M	6.17	9.00
Paul	10G	M	4.50	6.18
Tafruz	10G	M	6.10	9.14
Morgan	9Y	M	5.12	8.00
Kylie	9Y	F	6.02	9.22
Sadia	10G	F	5.35	9.10
Scott	9Y	M	4.34	7.40
Clare	10G	F	5.06	9.30

Look at the results in the table. Make a list of some ideas that you could investigate.

Use the data to investigate as many of your ideas as you can.

Try and give reasons for the things you find out.

Appendix 18 Assessment criteria for short context questions

Chocolate Splits and Tug of War

Grade 1 was given if students gave the answer 1, either as an answer or in a worked example.
Grade 2 was given if students gave the answer 2.
Grade 3 was given if students gave an answer other than 1 or 2.
Grade 4 was given for failing to attempt the task.

Cutting Wood and Fashion Workshop

Grade 1 was given if students put all of the numbers into the minimum groups possible.
Grade 2 was given for putting all or most of the numbers into groups, not using the most efficient groupings but showing a good understanding of the task.
Grade 3 was given for attempting the task without forming any 'sensible' groups.
Grade 4 was given for failing to attempt the task.

Penalties, Fractions and Plants

Grade 1 was given if students explained correctly why one fraction was bigger than another using either self generated methods or school taught algorithms.
Grade 2 was given if students explained why one fraction was bigger than another using methods which were insufficient to differentiate the fractions but demonstrating a realisation that fractions represent proportional amounts.
Grade 3 was given if students only used:

(i) the numerator, goals scored or plants grown
(ii) the denominator, penalties missed or plants that died
(iii) the difference between numerator and denominator

Grade 4 was given if students did not attempt the question.

The Letter 'T' and Fences

Grade 1 was given if students gave the correct answer (Fences: $35m^2$, T: $24cm^2$, units not essential)
Grade 2 was given if correct dimensions of the fences or the T were given without the area
Grade 3 was given if students found incorrect dimensions e.g. by not taking account of the shed or divided the two numbers given in T.
Grade 4 was given for another answer e.g. fence ÷ 3, 3 x 28 = T
Grade 5 no answer.

Appendix 19 Cross-tabulation of pairs of year 9 context questions

Amber Hill and Phoenix Park (%)

Chocolate Splits and Tug of War

Amber Hill

Tug				
4	2	1	1	
3	2	1	2	1
2	5	36	2	
1	41	5	3	
Chocolate splits	1	2	3	4

same grade: 79%

Phoenix Park

Tug				
4				1
3			1	
2	4	49	3	
1	37	5	1	
Chocolate splits	1	2	3	4

same grade: 88%

Cutting Wood and Fashion Workshop

Amber Hill

Wood				
4		2		4
3	4	5	4	4
2	10	7	1	1
1	43	9	6	
Fashion workshop	1	2	3	4

same grade: 57%

Phoenix Park

Wood				
4	3		1	
3	2	4	5	2
2	10	11	3	5
1	44	8	3	
Fashion workshop	1	2	3	4

same grade: 61%

Penalties and Plants

Amber Hill

Pens	1	2	3	4
4		1	0	
3			91	2
2		2	1	
1	2		1	

Plants

same grade: 97%

Phoenix Park

Pens	1	2	3	4
4				1
3		1	91	
2		1		
1	4		2	

Plants

95%

Penalties and Fractions

Amber Hill

Pens	1	2	3	4
4		1		
3		4	80	9
2		3		
1	1		2	

Fractions

same grade: 85%

Phoenix Park

Pens	1	2	3	4
4				1
3	0	3	91	8
2				1
1	4	2		

Fractions

94%

Fractions and Plants

Amber Hill

Fracts					
	4			9	0
	3	2	3	75	2
	2			7	
	1			1	
		1	2	3	4

Plants

Phoenix Park

Fracts					
	4			8	2
	3	3	1	75	2
	2		1	4	
	1	1		3	
		1	2	3	4

Plants

same grade: 83% 80%

Appendix 20 Architecture short test results (n)

Amber Hill

	1	2	3	4	total
rectangle	14	10	14	13	51
cuboid	14	11	14	10	49
prism	14	8	7	7	36
%	12	3	10	12	37
road	14	11	12	14	51
scale	13	8	10	13	44
angle	14	11	13	12	50
total	14	11	14	14	

all groups	rectangle	cuboid	prism	%	road	scale	angle
✓	51	49	36	37	51	44	50
✗	2	4	17	16	2	7	3

Phoenix Park

	a	b	c	d	total
rectangle	12	13	12	13	51
cuboid	13	12	12	13	50
prism	11	5	11	7	34
%	7	6	11	8	32
road	12	11	12	10	45
scale	11	9	10	9	39
angle	13	11	12	12	48
total	13	13	12	13	

all groups	rectangle	cuboid	prism	%	road	scale	angle
✓	51	50	34	32	45	39	48
✗	0	1	17	19	6	12	3

Appendix 21 Assessment criteria for the architecture activity

Volume Problem

Grade 1 was given if the students worked out the correct overall percentage of roof space to house space, or if they mismeasured the plan or model but used the correct methods.

Grade 2 was awarded if the students worked out the volume of the roof and / or the house but didn't calculate one as a percentage of the other.

Grade 3 was awarded if the students showed some measurements with no volume calculations or incorrect volume calculations.

Grade 4 was awarded for a non-sensical answer, showing no understanding of the problem.

Angle Problem

This was marked on a right or wrong basis. The correct answer was the angle of the roof was less than 70 degrees (and therefore failed the council rule).

All students attempted both problems.

Appendix 22 Assessment Criteria for Planning a Flat

The Activity

Flat Design

1. Appropriate sized rooms, good access throughout the flat, attends to both constraints, furniture, doors, corridors all appropriate sizes.

2. Appropriate sized rooms, access OK, complies with constraints but furniture, doors, or corridors wrong sizes.

3. Appropriate sized rooms but no access to some rooms or furniture.

4. Ignores one or two of the constraints.

5. Realistic room sizes only.

Flat Design Notes

1. States who the flat is for and gives advantages and disadvantages of design.

2. States who the flat is for and shows evidence of thought about suitability of design.

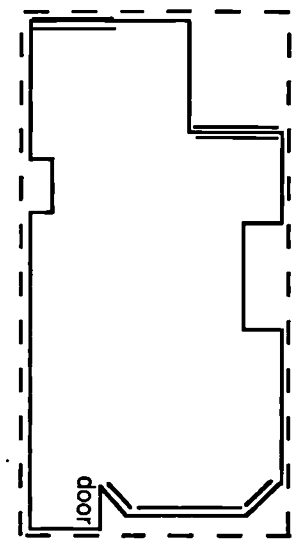
3. States who the flat is for.

4. Nothing written.

Planning a Flat Questions

Area of the flat

1. Works out a correct approximation of the area of the flat based upon all of the space which carpet would need to be bought for ie the rectangle shown below or a similar approximation.



2. Works out a correct area for the exact floor space of the flat having subtracted the 'spaces' by the bay window, the chimney breasts and the space by the window at the top of the flat

3. Uses 'whole room' method (as in 1) but incorrect use of scale gives wrong answers.

4. Uses 'subtracted room' method (as in 2) but incorrect use of scale gives wrong answers.

5. Uses 'whole room' method (as in 1) but incorrect calculation of area.

6. Other wrong attempt.

7. No answer.

Bank Loan

1. Rounds up to nearest ten or one hundred pounds.

2. Rounds down and borrows elsewhere.

3. Gives the exact price of the carpet to the nearest pound.

4. Other.

5. No answer.

Angle

1. Correct estimation of angle.

2. Gives the answer 'yes' but gives inappropriate or no explanation.

3. Wrong estimation of angle.

4. No answer.

Appendix 23 Planning a Flat short test results

All groups:	area		scale		angle		%	
	✓	✗	✓	✗	✓	✗	✓	✗
Amber Hill	90	2	83	9	87	4	39	52
Phoenix Park	59	16	67	9	64	13	10	72
			$\chi^2 = 0.18$				$\chi^2 = 19.97$	
sig level	$p = 0.0001$*		$p < 0.90$		$p = 0.004$*		$p < 0.001$	

* calculated using Fisher's exact test because numbers in cells less than 6

Test Results by group

Area:

Amber Hill	set: 1	2	3	4
✓	29	21	23	17
✗	0	2	0	0

Phoenix Park	gp: a	b	c	d
✓	12	15	19	13
✗	8	6	0	3

Scale:

Amber Hill	set: 1	2	3	4
✓	26	22	19	16
✗	3	1	4	1

Phoenix Park	gp: a	b	c	d
✓	20	16	18	13
✗	0	5	1	3

Angle:

Amber Hill	set: 1	2	3	4
✓	26	22	22	17
✗	3	0	1	0

Phoenix Park	gp: a	b	c	d
✓	15	20	16	3
✗	5	2	3	3

%:

Amber Hill	set: 1	2	3	4
✓	26	0	6	7
✗	3	22	17	10

Phoenix Park	gp: a	b	c	d
✓	4	4	0	2
✗	16	18	23	15

Appendix 24 Cross-tabulation of pairs of year 10 context questions

Amber Hill and Phoenix Park (%)

Chocolate Splits and Tug of War

Amber Hill (rows: Tug; columns: Chocolate splits)

Tug	1	2	3	4
4	1			2
3	1			
2	6	31	2	1
1	53	3	1	1

same grade: 86%

Phoenix Park (rows: Tug; columns: Chocolate splits)

Tug	1	2	3	4
4	1			2
3		4		
2	4	35	2	2
1	47	2		

same grade: 84%

Cutting Wood and Fashion Workshop

Amber Hill (rows: Wood; columns: Fashion workshop)

Wood	1	2	3	4
4	3	1		3
3	2	3	1	2
2	12	2	2	1
1	48	16	3	3

same grade: 54%

Phoenix Park (rows: Wood; columns: Fashion workshop)

Wood	1	2	3	4
4	4	2	4	12
3	1	2	1	2
2	1	8	1	4
1	34	8	4	12

same grade: 55%

Penalties and Plants

Amber Hill

Pens \ Plants	1	2	3	4
4			2	2
3	1	1	81	1
2	1	2	2	
1	4		1	2

same grade: 89%

Phoenix Park

Pens \ Plants	1	2	3	4
4			2	2
3	1		74	5
2		6		1
1	7		1	

same grade: 89%

Penalties and Fractions

Amber Hill

Pens \ Fractions	1	2	3	4
4	1		2	3
3	4	12	57	10
2	1	2	2	
1	4	1	1	1

same grade: 66%

Phoenix Park

Pens \ Fractions	1	2	3	4
4			5	5
3	4	2	60	15
2		5	1	1
1	7			1

same grade: 77%

Fractions and Plants

Amber Hill

Fracts	Plants 1	Plants 2	Plants 3	Plants 4
4			11	2
3	1		59	1
2	2	2	11	1
1	3	1	5	1

Phoenix Park

Fracts	Plants 1	Plants 2	Plants 3	Plants 4
4	2		15	6
3		1	58	1
2		5	2	
1	6		4	1

same grade: Amber Hill 66% Phoenix Park 75%

The Letter T and Fences

Amber Hill

T	Fences 1	Fences 2	Fences 3	Fences 4	Fences 5
5	1		2	9	17
4	2	1	1	30	9
3			1	1	
2			1	4	1
1	9	1	2	8	3

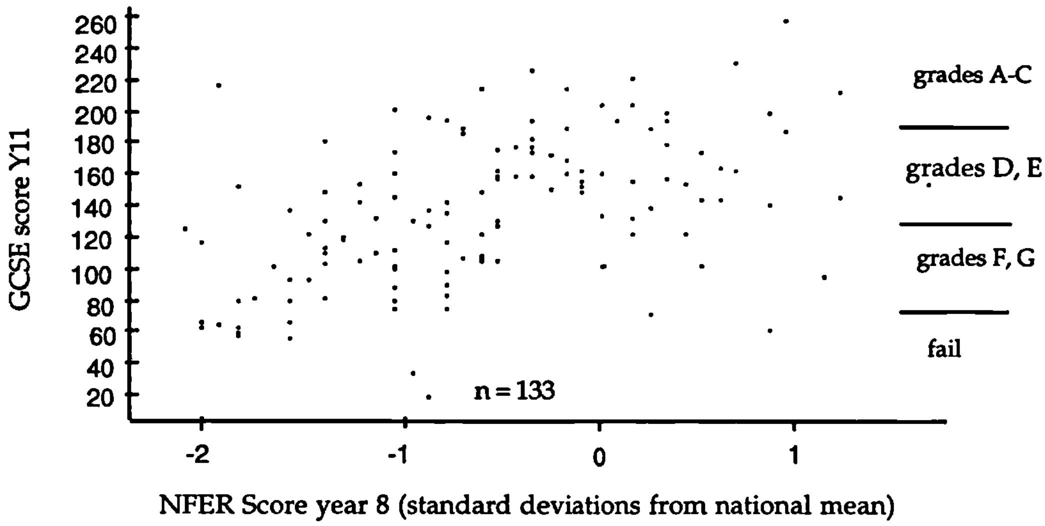
Phoenix Park

T	Fences 1	Fences 2	Fences 3	Fences 4	Fences 5
5			1	11	15
4		1	8	22	4
3			6	5	2
2			2	1	1
1	6	2	6	7	

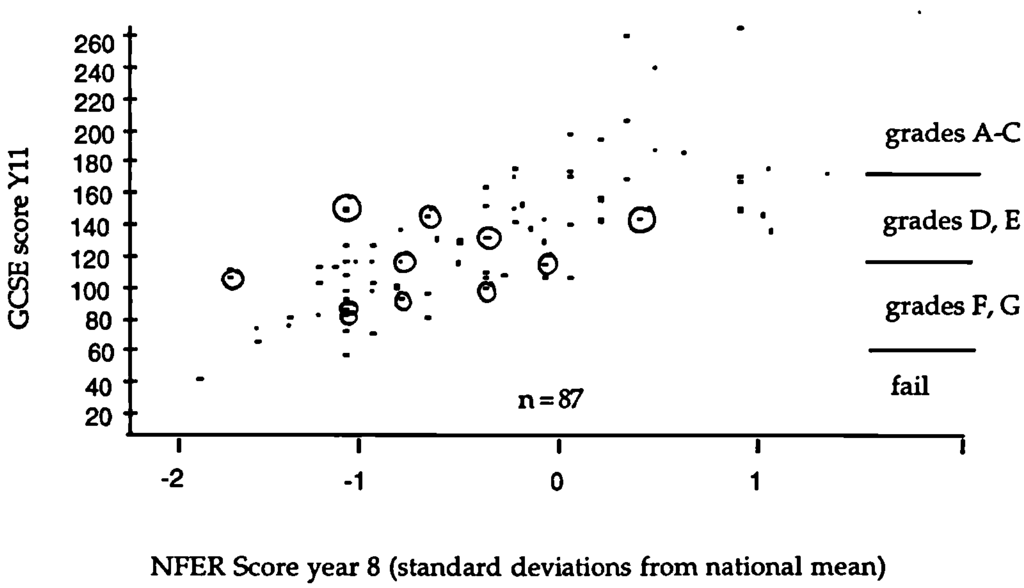
same grade: Amber Hill 57% Phoenix Park 49%

Appendix 25 Scatterplots NFER v GCSE Scores

Relationship between GCSE grade and NFER entry scores at Amber Hill



Relationship between GCSE grade and NFER entry scores at Phoenix Park



Note: the actual GCSE *scores* at the two schools are not directly comparable because the schools used different examination boards.

	Amber Hill	Phoenix Park
Correlation between GCSE score and NFER score	0.48	0.67

Appendix 26: English and Mathematics GCSE Results

Amber Hill and Phoenix Park (%)

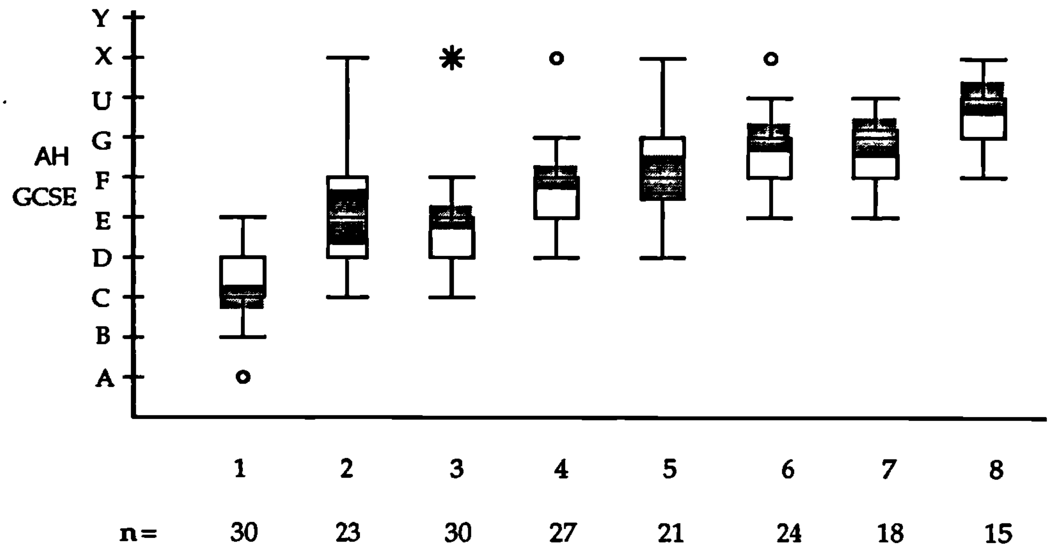
Percentages of entrants attaining grades A-C and A-G at each school

Amber Hill:	Mathematics	English
A-C	14	36
A-G	84	100

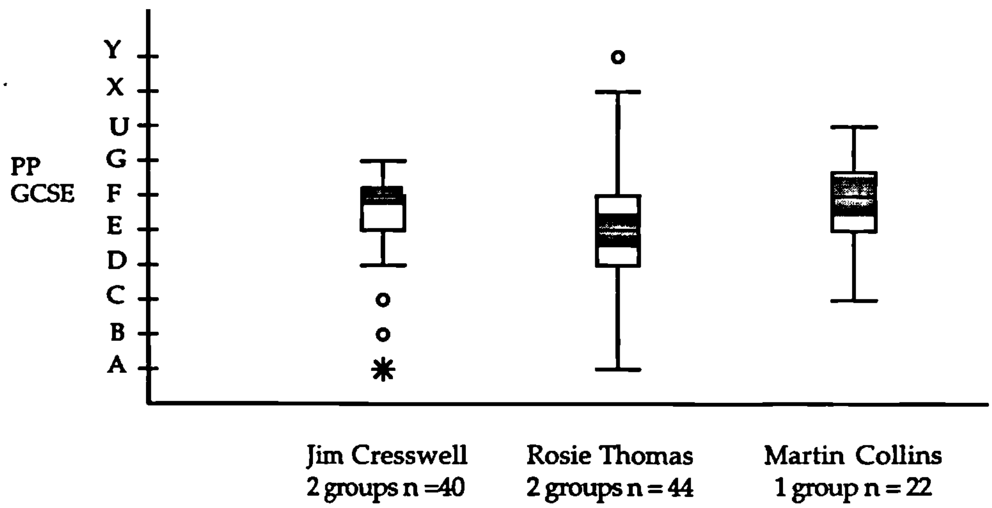
Phoenix Park:	Mathematics	English
A-C	12	28
A-G	94	93

Appendix 27 Comparison of GCSE grade and teacher / set

Amber Hill sets



Phoenix Park mixed ability groups



Appendix 28 Interview Questions

Year 10 Student Interview Questions

1. Can you describe a typical maths lesson for me - in as much detail as possible?

2. What is the difference between maths in years 7 and 8 and maths in year 9 and above? / maths at middle school, maths at PP?

3. What do you like and dislike about maths?

4. How would you change maths lessons if you could?

5. Are maths lessons different for girls and for boys or the same?

6. Do you feel that you have some choice about the work you do in maths?

- can you choose what questions / activities to do?, can you explore topics that you are interested in or take things further if you want to?

7. When you work hard in a lesson, why is it, what motivates you to work hard?

8. Do you generally understand what you are doing in maths?

9. Do you discuss things in maths? Is this a good thing?

10. Do you think you will be able to use what you have learned in maths in, say a few months or a few years?

11. Do you generally know why you are doing the things you do in maths?

12. Can you think of a time when you had to *use* maths in a lesson in the sort of way you would in the 'real world'?

13. Is maths important? If so why or why not?

14 Teachers try and get you to do two things in subjects, one of them is to understand what they are telling you, another is to remember things, for example, remember a method. Some subjects are more of one and some more of the other, is maths more about understanding something or remembering a method that works?

15. Describe a maths lesson which you have enjoyed and one which you haven't.

16. When you do something with maths in it outside of school is it different or similar to using maths in school?

Year 11 Student Interview Questions

1. You're coming to the end of your maths education, after 11 years, if I asked you to summarise for me the maths you have done at AH/PP what would you say?

2. Can you think of a maths lesson you have really enjoyed, one that stands out in your mind & one that you have really disliked?

3. What did you think about about doing coursework?

4. How does maths compare to other subjects at the school, is it similar in approach?

5. Imagine you're starting a new problem in your book, you read through it and you don't know where to start, what do you do?

- if you ask the teacher what do they say?

- do teachers encourage you to think about what you are doing in a general sense eg what does it all mean? or do they tell you what to do bit by bit?

6. How important is it to you to get a good grade in maths? why?

7. Is maths a subject when you have to be self motivated and self disciplined, think for yourself?

8. How much freedom and choice is there in maths?

9. When you do different topics in maths, does the teacher explain how they are connected? are they linked?

10. How would you change maths lessons if you could?

11. How do you feel about being in set x?, what do you think is different in the environment of your set compared to other sets? / what do you think about being taught in sets compared to mixed ability groups?

12. Are you looking forward to leaving school?, do you enjoy school?

13. Is the work you have learned in maths going to be useful to you when you finish?

- do you generally know why you are doing the things you are doing in maths?

14. When you work hard in maths why is it?

- because of the teacher?, because the work is interesting?, because you want to do well?

15. Can you think of any situations outside of school when you have used maths?

- do you think back to and use school methods or do you use your own methods?

- does it feel like doing maths in school or does it feel different?

16. After you have done work, how long can you remember it?, is it easy to remember over long periods of time? - until the review, until it comes up in the next book? for months?

17. In SMP you usually do something in 1 book and then again in another, are you able to build on what you did in the first or have you usually forgotten it?

18. Is there a lot to learn and remember in maths?

19. How did you get on in your mocks?

Teacher Interview Questions: beginning of the research

1. What do you think are the strengths and weaknesses of the maths National Curriculum?

2. Out of all the students you teach, who is the best mathematician and why?

3. Think of a lesson that went well, what was good about it?, think of a lesson that went badly, what was bad about it?

4. Can you describe your ideal maths lesson?

5. What are your views about mixed ability teaching, as opposed to setting in maths?

6. Describe the maths teaching approach in your school as if I knew nothing about it.

7. What do you think are the strengths and weaknesses of this approach?

8. What is your interpretation of the term 'using and applying maths' - what do you think it involves?

9. When do pupils 'use and apply' maths in your scheme / approach?

10. What do you think is the relative importance of process and content in maths?

11. How important is group work in maths teaching?

12. What is different about the mathematical experience of students in years 7 and 8 and students in year 9 and above?

13. What do you think is the best way of finding out much students have learned in a topic?

14. Why do you think it is that students often leave school and are unable to use the maths they learn in school?

15. What can we do about that?

Teacher Interview Questions: end of the research

1. What do you think about textbooks, individualised booklets and coursework - which is the most popular? with whom? why?

2. Which do you think is the best approach to use for : high flyers, low attainers, girls, boys?

3. What do you think about the proportion of each used in the school?

4. How did the students get on at GCSE? - & relative to other subjects?

5. How did the girls get on relative to the boys?

6. Has the National Curriculum had any effect upon what or the way you teach?

7. If you have a student who is particularly bad at applying work, what do you do? what is the best way to make provision for them?

8. From my research, the major problem for the students seems to be...

9. Do you think there are any advantages or disadvantages for the students of being in sets / mixed ability groups?

10. If you imagine 2 schools at opposite ends of the spectrum - one that uses textbooks, one that uses projects all of the time, which would you rather teach in? why?